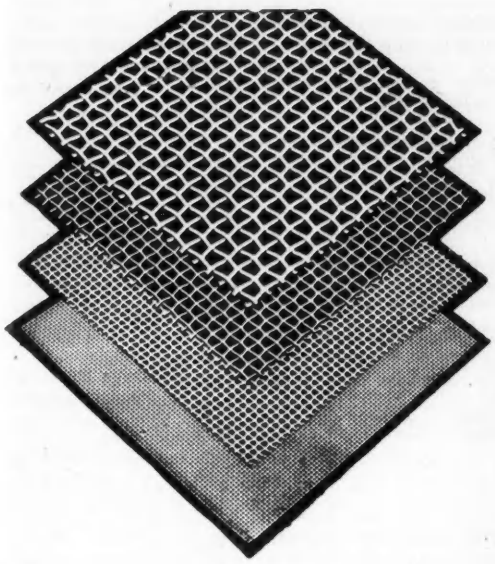

Very Versatile

IN many different metals, coarse mesh or fine, light gauge or heavy, 'Harco' Woven Wire is finding its way into more and more industries.

For Screening, Sorting or Sifting it is used in the grading of many types of material and products, from heavy minerals to fine powders.

For Filtering it plays a vital part in many kinds of mechanical equipment, and in the processing of liquids.

For Restricting Access—whilst allowing for the free passage of air—it is used for such diverse purposes as shielding commutators and excluding the common fly.

For Reinforcing Sheet Materials it gives greatly enhanced strength without sacrifice of flexibility.

For Improving Presentation its appearance and adaptability are important factors in industrial design.

'Harco' Woven Wire

Please ask for Catalogue No. E269.

Harvey

G. A. HARVEY & CO. (LONDON) LTD.,
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THE ENGINEER

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

SUBSCRIPTIONS

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

BRADFORD EDUCATION COMMITTEE

TECHNICAL COLLEGE BRADFORD

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for appointment as SENIOR LECTURER IN MECHANICAL ENGINEERING in the College. Candidates should be able to offer Applied Thermodynamics.

The salary scale for men (according to the Burnham Technical Award) will be from £1065 to £1215 per annum.

Conditions of the appointment and forms of application may be obtained from the Director of Education, Town Hall, Bradford, 1, and completed forms should be returned to the Principal of the College as soon as possible.

A. SPALDING,
Director of Education.
E7181

BUCKINGHAMSHIRE EDUCATION COMMITTEE

HIGH WYCOMBE COLLEGE OF FURTHER EDUCATION

Principal : W. J. DAVIES, J.P., B.Sc.

LABORATORY ASSISTANT

LABORATORY ASSISTANT required to maintain equipment in engineering and applied science laboratories. Experience in maintenance of heat engines and in use of machine tools desirable. Salary, £425 to £500 per annum.

Applications in writing with copies of two recent testimonials must reach the Principal, High Wycombe College of Further Education, Easton Street, High Wycombe, within ten days of the appearance of this advertisement. E7179

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

A.E.R.E. HARWELL, BERKS

PROJECT ENGINEERS

The United Kingdom Atomic Energy Authority, A.E.R.E., Harwell, Berks, requires PROJECT ENGINEERS to work in collaboration with scientific staff on the engineering of plant and/or experimental equipment, including design investigation. To give engineering direction throughout drawing office, manufacturing, installation and commissioning stages. Candidates should have served a recognised engineering apprenticeship and possess Corporate Membership of one of the Senior Institutions, or have exempting qualifications. They should have had experience in the design and manufacture or commissioning and operation of mechanical, chemical or electro-mechanical plant. Experience in the preparation of overall programmes and their execution would be an advantage. Appointments, according to age, experience and qualifications, will be made either in the grade of Engineer II (£995–£1275 per annum) or Engineer III (£645 (at age 25) to £995 per annum). Applications should be sent to Establishments Officer, United Kingdom Atomic Energy Authority, A.E.R.E. Harwell, Didcot, Berks, quoting reference 2/103/215. E7191

BRITISH ELECTRICITY AUTHORITY

HEADQUARTERS, LONDON

SENIOR ASSISTANT ENGINEER

British Electricity Authority, Headquarters, London, require a SENIOR ASSISTANT ENGINEER, to be responsible for co-ordinating construction work at a group of power stations.

Duties will entail attendance at site meetings and visits to power stations. Practical experience in construction of modern power stations, including handling of contracts, preparation of commissioning programmes, work on site and co-ordination of projects from inception to commissioning is essential.

Candidates should preferably be Corporate Members of the I.Mech.E. or I.E.E.

Salary, N.J.B. Grade 1, £1150–£1500 p.a. inclusive.

Applications, stating age, qualifications, experience and present position and salary, should be forwarded to Director of Establishments, Winsley Street, London, W.1, by 17th January, 1955. Quote Ref. ENR./551. E7178

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

ELECTRICAL ENGINEER

The United Kingdom Atomic Energy Authority, at Capenhurst, near Chester, requires an ELECTRICAL ENGINEER to supervise the installation of large electric power systems including high tension transformers and switchgear, power cables and electrical rotating machinery.

Qualifications : recognised engineering apprenticeship and A.M.I.E.E., or equivalent qualifications, with experience in the installation and commissioning of high tension sub-stations and distribution systems or large electrical rotating machinery.

Rate of Pay : £1330–£1511. The successful candidate will later be required to join the Authority's contributory pension scheme and salaries will be increased to cover contributions.

Applications to United Kingdom Atomic Energy Authority, Industrial Group Headquarters, P.O. Box 19, Risley, Warrington, quoting 762. E7196

PUBLIC APPOINTMENTS

STAFFORDSHIRE POTTERIES WATER BOARD

PECKFORTON PUMPING STATION

APPOINTMENT OF FOREMAN

Applications are invited for the above appointment from suitable candidates, not exceeding 45 years of age, who must have received a sound engineering training and subsequent experience with diesel engines and electrical pumping plant.

The appointment will be on the permanent establishment at a salary in accordance with the amended Grade A.P.T. I (£500 per annum, rising to £580 per annum) of the Administrative, Professional and Technical Division of the National Scheme of Conditions of Service for Local Authorities. In addition a modern house will be provided rent and rates free.

Previous experience with a Water Authority is desirable though not essential.

The Peckforton Pumping Station is in progress of development and it is likely that there will be opportunity of re-grading at some future date.

Applications, in the candidates' own handwriting, stating age, qualifications and full details of present and past positions, together with copies of two recent testimonials, must be delivered to the undersigned not later than Friday the 7th January, 1955, the envelope being endorsed "Foreman, Peckforton Pumping Station."

The post will be subject to the Local Government Superannuation Acts and Regulations and to the selected candidate passing a medical examination.

C. V. BROWN, M.I.C.E., M.I.Mech.E., M.I.W.E.
Engineer and Manager and Clerk to the Board.
Albion Street,
Hanley,
Stoke-on-Trent. E7193

AIR MINISTRY

LONDON

DESIGNER-DRAUGHTSMEN

Air Ministry require in London DESIGNER-DRAUGHTSMEN for bulk petroleum storage and pumping installations, experienced in one or more of the following :—(a) storage tank layout and design, (b) pump house and plant layout, (c) development of pipeline schemes, (d) hydraulic calculations. Technical training to O.N.C. standard required. Salaries up to £670 p.a., starting pay based on age, qualifications and experience. Overtime payable. Promotion prospects and long-term possibilities. Natural-born British subjects only.—Write, stating age, qualifications, employment details, including type of work done, to Ministry of Labour, 236, Walworth Road, London, S.E.17, quoting Order 3593. E6930

LINCOLNSHIRE RIVER BOARD

SURVEYOR/DRAUGHTSMEN

Applications are invited for the appointment of two SURVEYOR/DRAUGHTSMEN, at a salary in accordance with the following scale :—£540 per annum by £20 to £580 per annum, for duty in the office of the Engineer of the Board at Boston. The appointments will be subject to the provisions of the Local Government Superannuation Acts and to one month's notice on either side. The persons appointed will be required to use their own cars in connection with their duties and an essential user's allowance will be paid by the Board.

Applications, giving full details of the applicant's education, qualifications and experience, together with the names of two referees, should be submitted to the undersigned not later than 10th January, 1955.

G. B. PHILLIPPO,
Clerk of the Board.
50, Wide Bargate,
Boston, Lincs. E7126

CRAWLEY DEVELOPMENT CORPORATION

CRAWLEY NEW TOWN

ASSISTANT ENGINEER (WATER)

Crawley Development Corporation require a qualified ASSISTANT ENGINEER (WATER), experienced in a water undertaking, preferably on distribution side. Salary scale £715 to £960 p.a., with placing in scale dependent upon qualifications and experience. Housing accommodation will be provided.

Application forms from Chief Engineer (Vacancy), Broadfield, Crawley, Sussex, should be returned by 14th January, 1955.

C. A. C. TURNER,
Chief Executive.
E7211

CITY OF SALISBURY

SOUTHERN RHODESIA

CIVIL ENGINEERS, GRADES II AND III

Airmail applications from qualified Civil Engineers for the following posts will be accepted up to and including 19th January, 1955 :—

CIVIL ENGINEERS, GRADE II : £1250 by £50 to £1450 p.a. (Associate Membership plus at least three years' experience after qualifying.)

CIVIL ENGINEERS, GRADE III : £980 by £50 to £1280 p.a. (B.Sc., or Parts 1 and 2.)

Further information may be had from the undersigned.

CITY ENGINEER.
P.O. Box 1583,
Salisbury,
Southern Rhodesia,
20th December, 1954. E7203

PUBLIC APPOINTMENTS

CHESTERFIELD, BOLSOVER AND CLOWNE WATER BOARD

APPOINTMENT OF ENGINEER AND MANAGER

Applications are invited for the position of ENGINEER AND MANAGER to the Board. The salary scale to be paid will be the standard salary (Scale C) prescribed by the Joint Committee for Water Engineers' Salaries, plus 5 per cent., namely, £1680 by £63 to £1932 per annum. A house will be provided for the successful applicant, for which he will be required to pay £100 per annum to cover rent and rates.

Applicants must be Corporate Members of the Institution of Civil Engineers and have had considerable experience in responsibility in the construction, operation and maintenance of waterworks undertakings.

The position is subject to the provisions of the Local Government Superannuation Acts, 1937–1953, and the successful applicant will be required to pass a medical examination.

Applications, accompanied by copies of three recent testimonials, should be sent in an envelope endorsed "Water Engineer," to the undersigned not later than 22nd January, 1955. No form of application has been prescribed.

RICHARD CLEGG,
Clerk to the Board.
Town Hall,
Chesterfield. E7206

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

CIVIL ENGINEERS

The United Kingdom Atomic Energy Authority requires CIVIL ENGINEERS for (a) the supervision at Calder Works, Cumberland, and Dounreay, Caithness, of work carried out by contract on major construction sites, involving experimental and power reactors, electrical generating plant, cooling towers, and mechanical works, and allied civil engineering activities, and (b) the supervision, at Dounreay, Caithness, of sections of work of a building and civil engineering character, involving either heavy reinforced concrete and steel structures, roads, drainage and water supplies, or the construction of ancillary buildings.

Qualifications : Corporate Membership of the Institution of Civil Engineers, or equivalent qualifications, with outside experience in the appropriate field of work. Applicants for (a) should have had considerable practical experience, preferably with direct control of construction labour, and an Honours Degree in Civil Engineering would be an advantage.

Rate of Pay : (a) £1330–£1511 and (b) £995–£1275, according to qualifications and experience. The successful candidates will later be required to join the Authority's contributory pension scheme and salaries will be increased to cover contributions. Applications to United Kingdom Atomic Energy Authority, Industrial Group Headquarters, P.O. Box 19, Risley, Warrington, quoting 763. E7195

SUNDRIDGE HOSPITAL

SUNDRIDGE, Nr. SEVENOAKS, KENT

RESIDENT ASSISTANT ENGINEER

RESIDENT ASSISTANT ENGINEER required for 184 bedded hospital. Salary, £425–£500 p.a., according to experience. Applicants should have completed practical training in mechanical engineering and possess Ordinary National Certificate in Mechanical Engineering or equivalent qualification. Consideration given to applicants completing studies for Certificate. Accommodation comprises unfurnished house in grounds at weekly charge of 14s. 10d. exclusive. Apply with age, experience, qualifications and 2 referees to Group Secretary, Orpington Hospital, Kent, by 10th January, 1955. E7177

COUNTY BOROUGH OF EAST HAM

JUNIOR MECHANICAL ENGINEERING ASSISTANT, NEW GRADE II

JUNIOR MECHANICAL ENGINEERING ASSISTANT, New Grade II, £560–£640.

London Weighting is paid in addition. Salary in excess of the minimum may be paid, according to qualifications and experience.

A subsistence allowance may be granted over a reasonable period to the person appointed if unable to obtain suitable housing accommodation, necessitating the maintenance of two homes.

Further details and application forms returnable by 14th January, 1955, from the Town Clerk, Town Hall, East Ham, E.6. E7175

BRITISH WELDING RESEARCH ASSOCIATION

GRADUATE ENGINEERS

Fatigue investigations, testing and stress analysis of welded structures. The British Welding Research Association requires GRADUATE ENGINEERS to join research teams working on these projects. Honours Engineering Degree essential, knowledge of engineering research practice and materials testing an advantage. Positions available in Research Officer (£450–£800 p.a.) and Senior Research Officer (£700–£1150 p.a.) grades, qualifying for membership of superannuation scheme (F.S.S.U.).—Written applications to Chief Administration Officer, B.W.R.A. Research Station, Abington Hall, Abington, Cambs. E1273

PUBLIC APPOINTMENTS

THE PARSONS AND MARINE ENGINEERING TURBINE RESEARCH AND DEVELOPMEN ASSOCIATION

CHIEF DESIGNER

The Parsons and Marine Engineering Tu Research and Development Association requi CHIEF DESIGNER. Must have experienc design of steam turbines. Experience in the d of gas turbines also will be an advantage.—A in confidence, giving full particulars of career salary required, to Research Director, Parso Research Station, Wallsend, Northumberland. E72

TENDERS

COUNTY BOROUGH OF WARRINGTON

OVERBRIDGE IN LIEU OF WILDERSP LEVEL CROSSING

The Council invites TENDERS for the C STRUCTION of a NEW STEEL and CONCR BRIDGE, about 30ft. span and 80ft. wide, approaches, brickfaced retaining walls and incidental works.

Drawings of the proposed works can be se the office of the Consulting Engineer, Mr. H FitzSimons, B.Sc., M.I.C.E., 39, Victoria S London, S.W.1, on week-days, excluding Mon and Saturdays, from 4th January, 1955, until January, 1955, between the hours of 11 a.m. a p.m., and also at the Borough Engineer's O Town Hall, Warrington, from 4th January, until 5th February, 1955, between the hours of 9 and 5.30 p.m. on Monday to Friday and 9 a.m. 12 noon on Saturdays.

Copies of the drawings and contract docu may be obtained at the above-mentioned addr upon payment of a deposit of £4 by cheque or made payable to the order of the Warrington Co Borough Council. The deposit will be returned bona fide Tender is submitted and not subsequ withdrawn.

Tenders on the official form which must be re before 9th February, 1955, should be sent in a envelope marked "Tender for Wilderspool Bri addressed to the Town Clerk, Town Hall, Wa ton, Lancs.

The Council do not bind themselves to accep lowest or any Tender.

J. P. ASPDEN,
Town Cle
E7127

INDIA STORE DEPARTMENT

AMENDED ADVERTISEMENT

The Director General, India Store Departm (MIS 2), Govt. Building, Bromyard Avenue, A London, W.3, invites TENDERS for the SUP of :—

ONE DIRECT OIL-FIRED TUNNEL K capable of firing 2 to 2½ tons of H.T. Elec Porcelains per day at a temperature of up 1350 deg. C. Complete with all accessories instruments including Kiln Cars and Car Furn for open set.

Forms of Tender which were originally ins return on Friday, 7th January, 1955, are now submitted on Friday, 4th February, 1955.

Forms may be obtained from this office (C Branch), on payment of a fee of 10s., which returnable.

Reference No. 511/53 (CDN) must be quoted applications. E7

EDUCATIONAL

UNIVERSITY COLLEGE LONDO

LECTURES

University College London (Gower Street, W —FOUR LECTURES by Professor F. Brail entitled "The Domain Theory of Ferromagnet will be given on Thursdays, 13th, 20th, 27th Janu February 3rd, at 5.30 p.m. Admission Free, wi Ticket.

E. A. L. GUETERBOCK,
Secretary
E7184

SITUATIONS VACANT

NOTIFICATION OF VACANCIES ORDER, 1952.

The engagement of persons answering advertisements must be made through a Local O of the Ministry of Labour or a Scheduled Em ment Agency if the applicant is a man aged inclusive or a woman aged 18–59 inclusive, unl or she, or the employment, is excepted from provisions of the Notification of Vacancies O 1952.

APPLICANTS ARE ADVISED TO S COPIES, NOT ORIGINALS, OF THEIR TE MONIALS UNLESS OTHERWISE REQUES

A MECHANICAL ENGINEER, preferably experience of metallurgy and metal working treatment processes, required as MECHAN ENGINEERING SALES MANAGER by L export firm, progressive and well established. tion offers excellent prospects to competent energetic man willing to travel when required. 30–45 years, languages an advantage, though essential. Applications.—BOX No. E1267, Engineer."

THE ENGINEER

DECEMBER 31, 1954

Safety in Mines Research

THE thirty-second annual report on safety in mines research has been published this week by H.M. Stationery Office. It summarises the work done during the year 1953 by the Safety in Mines Research Establishment of which Mr. A. H. A. Wynn is the director. The report records that on February 22, 1953, the Minister of Fuel and Power reappointed a Safety in Mines Research Advisory Board, under the chairmanship of Mr. E. G. Fudge, its terms of reference being "to keep under review and advise on the general scope, organisation and progress of the Ministry's research work on safety in mines." Among the items discussed by the board at its meetings were blasting techniques, wire rope research and testing, stone dust barriers and a paper dealing with safety problems arising from technical developments. Explosives and blasting devices forms one section of the report which deals with the new test procedure for Eq. S. and sheathed permitted explosives, pulsed infusion shot firing and electrical shot firing equipment, dust produced by shots in stone and explosively produced sprays to suppress dust. The next part of the report is concerned with the explosion hazard and refers to work on the measurement of coal dust deposition rates and the new quantitative chart of the coal-dust explosion hazard. There is a note upon rescue apparatus and the report continues with the question of the fire hazard, stressing the need to use fire-retardant timber, and notes the commendable performance of P.V.C.-coated cloths. The section concerning engineering and metallurgical research touches upon the development of hydraulic props, the design of roof bars and the value of fluorescent magnetic ink for detecting surface cracks. Another hazard mentioned is that of pneumoconiosis, linked with which is dust control, and the report notes that the design of improved dust sampling instruments has made some progress and that quartz may be a factor causing pneumoconiosis. Following a reference to the statistical study of accidents, the report continues with a section dealing with the testing services which tested and recommended twelve explosives for Eq. S. certificates, examined winding ropes and defective gear, and flameproof testing. The report concludes with synopses of research reports and papers published in 1953.

Production of Military Aircraft

BEFORE the House of Commons rose for the Christmas recess, the Prime Minister was asked if he would explain the system of co-ordination between the Ministry of Supply, the Air Ministry and the Admiralty for obtaining aircraft. The Prime Minister replied that any operational requirement was drawn up by the Service concerned and after detailed examination and acceptance by the Ministry of Supply a contract was placed for the design and development of the aircraft required. It was then the responsibility of the aircraft manufacturer to carry through flight and other tests until the company considered the aircraft met the specification. Further tests were then carried out by the Aeroplane and Armament Experimental Establishment of the Ministry of Supply. In the light of its report and in agreement with the service department, which was fully informed of developments, a release was given by the Ministry of Supply. Mr. Wyatt maintained that an "appalling delay" existed in the delivery of aircraft and asked if it was not time that the system was overhauled. Was it not one of the difficulties, he asked, that nobody had the power to decide when modifications should cease and production commence? The Prime Minister replied that the issue was very complex and had raised in his mind whether a special Ministry should be re-created to deal with production. Happily, he continued, "the delays . . . through accidents, through too few prototypes and through unfortunate and tragic events here and there, will not work out to our disadvantage." Mr. Callaghan then stated that these events certainly had resulted in a considerable loss of public money and that "some sort of committee" should be set up into the state of the whole aircraft industry to see whether the public was getting value for its money. When the Prime Minister suggested that the occasion of the Estimates was an admirable time for raising this issue, Mr. Callaghan asked the Prime Minister whether he realised that "this subject is far too complex, technical and detailed to be dealt with by exchanges across the Floor of the House." "I am rather shy of putting my faith on any matter of great intricacy in 'some sort of committee,'" the Prime Minister replied.

Wrought Non-Ferrous Metals Industry

THE British Productivity Council has published another of its series of reviews recording post-war development in certain British Industries. The new book is entitled *A Review of Productivity in the Wrought Non-Ferrous Metals Industry*, and in its opening pages it points out that few other industries in this country have been faced with more problems in the post-war years than that concerned with wrought non-ferrous metals. This industry, in addition to other difficulties common to all British industry during the past nine years, has suffered acute shortages of its main raw materials, sometimes reaching proportions of national crisis, and progressive increases in their cost. It has been subjected to long periods of Government control, intermittently relaxed and made more stringent, and it has seen many of its customers turn to alternative, sometimes less satisfactory, materials because of the uncertainty of non-ferrous metals supplies and prices. The ninety firms in the industry manufacturing semi-finished products of copper, zinc and the copper-rich alloys employ some 65,000 workers. About 8 per cent of the industry's output is exported directly, but it is estimated that about half of its production is accounted for in indirect exports. Productivity in the industry has never been statistically measured and to do so would be a task of considerable difficulty owing to the great variety of its products and differences in the sizes of the firms. The variety of products which is required by customers is a great deterrent to productivity and even the largest and most progressive firms seldom produce more than 50 per cent of their output in standard dimensions and alloys. The report says that simplification and standardisation would do much to increase productivity. In an appendix notes are given on the reforms adopted by ten firms in the industry to improve productivity.

Transport Problems in Europe

A REPORT from the United Nations Economic Commission states that decisions have recently been made on a number of important questions on transport by Eastern and Western European countries. It says that for the first time since the establishment of the E.C.E. Inland Transport Committee in 1947, Eastern and Western European Governments have agreed to exchange views on inland navigation problems. They have stressed the need for study of technical and administrative questions for inland navigation and have arranged for a meeting of representatives of interested Eastern and Western Governments and organisations to be held this coming spring. This meeting will consider inland navigation problems which it would be advisable to study within the committee, and propose procedures for such a study. It is to give attention to the drafting of an inland waterway transport contract as well as to the question of the possible revision of the three 1930 Conventions on river law. The inland transport committee has also requested its Working Party on Tariffs to work out uniform principles for the establishment of international tariffs in Europe. At present international tariffs are in most cases the sum of national tariffs and charges are calculated in each country on the basis of distance covered in that country. International tariffs are higher than if transport had taken place in one country where fixed charges and scales tapering with distance prevail. However, special international tariffs exist for certain classes of traffic. Moreover, eleven countries of Eastern Europe and Asia have applied a uniform transit tariff since 1951. The adoption of uniform principles for the establishment of international tariffs would facilitate trade and would simplify the work of those engaged in it, as well as the task of the railway administrations. The Working Party on Tariffs bas been instructed to take the various possible systems into account. The committee also discussed the progress of work under way on tariff differentiations and requested the Working Party to concentrate its attention on those which are unjustifiable from the standpoint of the European economy.

Institution of Mining Engineers

IT is announced that the sixty-first annual general meeting of the Institution of Mining Engineers will be held in London on January 27th next. At a luncheon which will follow the meeting, the Institution medal, the highest honour it can bestow, will be awarded to Sir Andrew Bryan in recognition of his distinguished services to coal mining, with particular reference to his contributions towards improvement of the safety, health, education and training of those engaged in the industry. During the course of the meeting a number of other awards are to be made. Dr. F. V. Tideswell, the senior principal scientific officer of the Safety in Mines Research Establishment, will receive the Douglas Hay medal for his contributions to problems of explosions and dust in mines. The Maskell Peace scholarship will be awarded to Mr. Peter Hackett; the Laurence Holland prize will be presented to Mr. N. A. Myhill, and the Sam Mavor students' prize to Mr. K. Wardell. Following the awards of these prizes, Mr. E. H. Browne will present his paper, "The Coalfields of Great Britain and their Future Development," for discussion by the meeting.

John Edward Sears

IT is with regret that we note the death of Mr. John Edward Sears, at the age of seventy-one, on Tuesday, December 21st. Mr. Sears received his early education at Mill Hill School and went on to St. John's College, Cambridge, where he took first-class mathematics and mechanical sciences tripos, and was awarded the University's John Winbolt Prize for studies in civil engineering. He also served an apprenticeship with Wigham Richardson, Ltd., Walker-on-Tyne. Mr. Sears subsequently entered the National Physical Laboratory and from 1921 to 1931 served as deputy warden of standards and later became superintendent of the Metrology Division, a position from which he retired in 1946. Mr. Sears was a member of the Institution of Mechanical Engineers and in 1948 he was awarded part of the Institution's Clayton Prize for his services to engineering science and manufacture by research and development in metrology and gauging. During his career Mr. Sears served as president of the International Committee of Weights and Measures, and he was a member of British Standards Institution Committees. He was made a C.B.E. in 1920.

Recent Studies of Metallic Friction

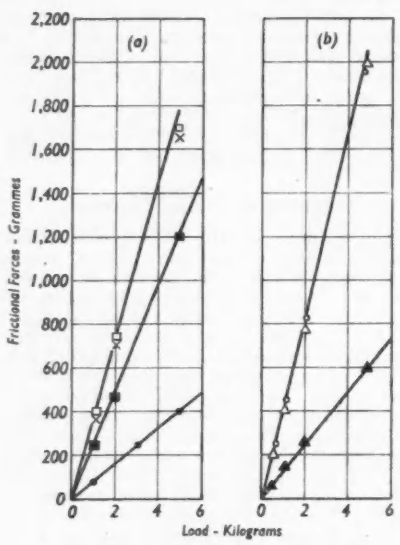
By F. P. BOWDEN, Sc.D., D.Sc., F.R.S.*

No. II—(*Concluded from page 889, December 24th*)

In the Thomas Hawksley Lecture delivered before the Institution of Mechanical Engineers on Friday, December 17th, Dr. Bowden reviewed existing scientific knowledge about friction. In the latter part of the Lecture here reproduced, he studied friction in skiing, sliding friction at very high speeds up to 2000 m.p.h., and at very high temperatures, and rolling friction.

Friction in Skiing and the Development of Some New Fast-Running Ski

ICE is an interesting substance since its friction can be lower by an order of magnitude than that of most other crystalline solids. The problem was discussed by Osborne Reynolds in about 1900, but he was rather diffident about it. He writes: "On trying to remember whether I had heard of any attempt to explain the slipperiness of ice in any way—for I felt at the moment as though everyone was laughing at me—I found that I could not recall any mention of the subject." He suggested



a On snow at −10 deg. Cent. *b* On sand.

The friction of cold snow is similar to that of dry sand. P.T.F.E. gives the lowest friction on both surfaces.

□ Perspex, $\mu = 0{\cdot}34$.
× Nylon, $\mu = 0{\cdot}30$.
■ Norwegian wax, $\mu = 0{\cdot}22$.
● P.T.F.E., $\mu = 0{\cdot}08$.
△ Perspex, $\mu = 0{\cdot}4$.
o Ski lacquer, $\mu = 0{\cdot}4$.
▲ P.T.F.E., $\mu = 0{\cdot}14$.

Fig. 7—Friction of small sledges

that the low friction in skating was due to a water film formed by pressure melting.

I might perhaps mention with equal diffidence that my interest in friction problems and the decision to try a few experiments began when snow-bound in the Concordia hut in the Bernese Oberland on a skiing expedition many years ago. I and my companions had been able to ski reasonably fast on snow at −20 deg. Cent., and it seemed highly improbable that pressure could produce melting at this temperature. Some years later, in collaboration with Dr. T. P. Hughes, I made at the Jungfraujoch Research Station an experimental study of the friction of ice and snow (Bowden and Hughes, 1939). The friction of cold snow or ice is very high. It is only at temperatures near 0 deg. Cent. that the friction is low. The experiments supported the view that the low friction is due to a surface melting. They showed, however, that pressure melting is a factor only at temperatures very close to 0 deg. Cent. and with slow-moving surfaces. If the sliding speed is appreciable and temperatures are below 0 deg. Cent., the local surface melting is produced, not by pressure melting, but by the frictional heating of the sliding surfaces. Under the conditions which obtain in skiing and sledging it is this frictional heating and melting which is the major factor responsible for the low friction. Experiments with sliders of different thermal conductance were in harmony with this view. These early experiments were carried out with miniature sliders, at most a few centimetres in area.

Recently (Bowden, 1953), I have had an opportunity of extending this work to real skiing and should like to mention briefly some of these results and, in particular, to describe the behaviour of some plastic materials sliding on ice and snow. The experiments supported the earlier conclusions that the low friction on snow and ice is due to a surface melting produced by the frictional heating of the sliding ski. The rubbing of the ski at the localised points of contact of the snow crystals causes a surface melting. At low temperatures the static friction of ice is high and it is not until the ski begins to slide at an appreciable speed that the friction falls to a low value.

Very cold snow or ice behaves like any other crystalline solid. Fig. 7 shows the static friction of a number of different surfaces sliding on snow at −10 deg. Cent. It will be seen that the friction is proportional to the load and the coefficient of friction (which is given by the slope of the line) is reasonably high for most solids. In fact, the friction of cold snow is very similar to the friction of dry sand. It should be noted that P.T.F.E. gives the lowest friction of all these surfaces.

The influence of temperature on the friction of a variety of surfaces sliding on snow is summarised in Fig. 8. Two important points to be noted here are, first, that the friction for all these surfaces falls as the snow warms up and is a minimum at 0 deg. Cent.

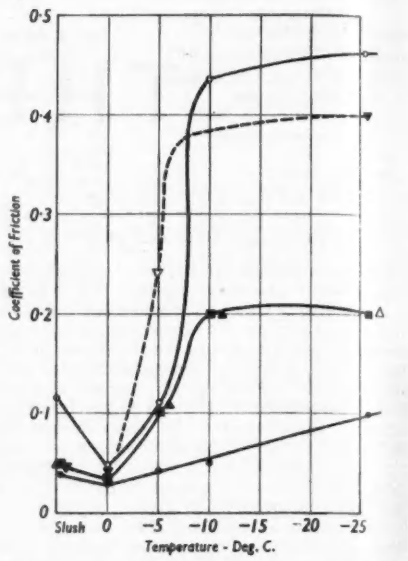
Table IV.—*Timed Descents: Comparison of Waxed Ski with "New" Ski (P.T.F.E.)*

a, Series 1: crystalline spring snow; air temperature, 5 deg. Cent.; snow temperature, 0 deg. Cent.; gentle slope of length 700ft (tracked)

Weight on ski, stone	Time of descent, seconds	
	Conventional ski with Norwegian wax and paraffin	"New" ski (P.T.F.E.)
12	61	42
10	83	54

b, Series 2: New snow fallen few hours previously; air temperature, 10 deg. Cent.; snow temperature, 0 deg. Cent.; unloaded ski (tracked)

Details of slope	Time of descent, seconds	
	Conventional ski with ski lacquer	"New" ski (P.T.F.E.)
Gentle, 20m long	10	6
Steeper, 30m long	6	3



At low temperatures the friction rises to a high value. It is to be noted that P.T.F.E. gives the lowest friction at all temperatures.
o Ski lacquer. ▼ Paraffin wax. ■ Norwegian wax.
△ Swiss wax. ● P.T.F.E.

Fig. 8—Influence of temperature on the static friction of real ski

when surface melting can most readily occur. The second point to be observed is the very low friction given by P.T.F.E. under all conditions. I think that this behaviour of P.T.F.E. is due partly to its inherently good frictional properties and partly to the fact that it is not wetted by water. We have evidence that the frictional behaviour of different solids is influenced by the contact angle which the water film makes with the surface. With P.T.F.E. this contact angle is very high. This suggests that P.T.F.E. suitably applied may have interesting possibilities for skiers or, at any rate, for those skiers who like to run fast.

Last March I made several pairs of ski coated with P.T.F.E. and tried them out in the Austrian Alps. The method used for attaching the P.T.F.E. is shown in Fig. 9. I also did some timed straight-run descents under controlled conditions. The results were quite striking and some typical experiments are shown in Table IV.

It is clear that the P.T.F.E. ski are very considerably faster under these conditions. They are very easy to ski on because they

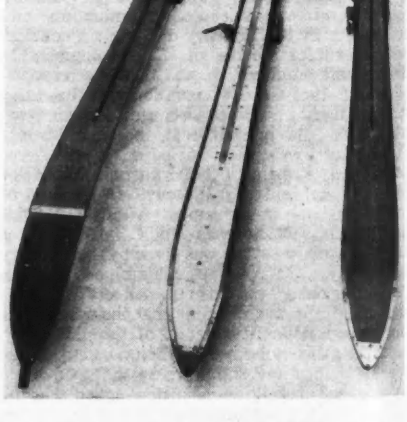


Fig. 9—Various methods used for attaching P.T.F.E. to the under surface of ski

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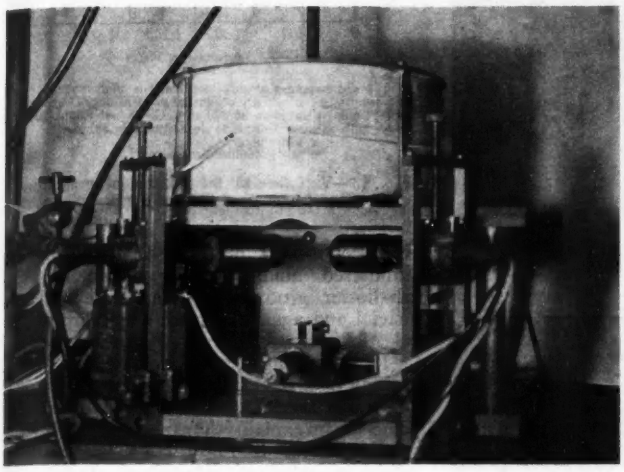
† Recently Dr. Anita Bailey and Dr. J. S. Courtney-Pratt (1954) have studied the behaviour of molecularly flat surfaces in contact. Their behaviour is quite different from that of ordinary solids and the usual "laws" of friction are no longer obeyed.

give a low uniform friction even when running on patchy snow. I think they may have important applications also to sledging and to aircraft landing, particularly on very cold, very wet or difficult snow and ice.

Sliding Friction at 2000 M.P.H.

In most of the work which I have been describing—and indeed in most engineering practice—the speed of sliding may vary from a few miles per hour up to, say, 20 to 50 m.p.h. What would happen if it were much faster ? The tendency in this age is to increase speed. What would happen to the friction and to the surfaces if they were slid together at speeds of 1000 to 2000 m.p.h.? Recently, in collaboration with Mr. E. Freitag, we have begun to make some study of the behaviour of metals and other solids which are sliding at these enormous speeds. In order to do this we have made use of an elegant technique for suspending and spinning a sphere which has been developed for other purposes by Professor Beams, of the University of Virginia (Beams, 1947).



(Driving coil out of position.)

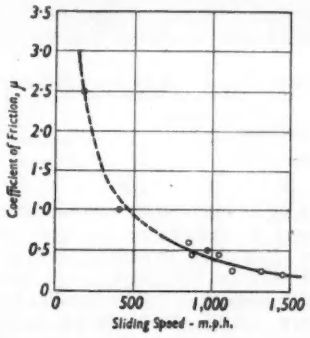
Fig. 10—Steel ball freely suspended in magnetic field

A metal sphere is suspended by an electro-magnet ; it is illuminated and the shadow falls on a photo-electric cell. If the ball sinks the current in the magnet will increase ; if it rises it will decrease so that it is held floating like Mohammed's coffin (Fig. 10). It can be caused to rotate by a rotating magnetic field. If the sphere is surrounded by an evacuated glass chamber the forces opposing its rotation will be very small indeed, and it will soon reach a very high speed (a million or more revolutions per minute). The speed is limited only by the rupture strength of the sphere. As the top of the ball is illuminated, an etch mark on the ball can be detected by means of a photomultiplier cell and transmitted to a cathode-ray oscillograph. The frequency of rotation can thus be measured accurately.

In our friction experiments the fast-spinning ball rubs against three symmetrically arranged vertical surfaces. All three are initially in such a position that they cannot interfere with the ball during its acceleration. Two of them are mounted rigidly and, when the desired speed is reached, a spring is released which pushes the third surface against the ball and thus moves it a very short distance sideways until it touches the two stationary surfaces. If the spring-operated surface is withdrawn, the ball returns quickly to its free-spinning position and can be slowed down in such a way that the high-speed wear marks are not further damaged. By measuring the loss of speed during a given sliding time under the known spring load, an average coefficient of friction is obtained.

In this way we are able to measure the friction and to study the physical processes occurring over an enormous range of speeds, up to 2000 m.p.h., or so. We have only just begun this work and the behaviour of the friction as one moves up to these very high speeds is shown in Fig. 11. These results were obtained with a steel sphere rubbing on a copper surface with a load of 10 grammes. The results are quite striking. At normal speeds the coefficient of friction is about $\mu=5$. One would expect this, because the surfaces are clean and are in a moderate vacuum. As the speed increases the friction decreases; at 500 m.p.h. it is $\mu=0{\cdot}9$. This decrease becomes more marked at higher speeds ; at 1000 m.p.h. it has fallen to $\mu=0{\cdot}3$, and at 1500 m.p.h. to $\mu=0{\cdot}2$.

Let us now examine the nature of the surface damage produced at these speeds. Fig. 12*a* shows the damage to the copper surface (melting point, 1083 deg. Cent.) when the sliding speed is a few feet per second. It shows characteristic abrasion and a high friction. Fig. 12*b* shows the damage at 500 m.p.h.; it is clearly different in character and shows obvious signs of surface flow. Fig. 12*c* shows the surface damage at 1200 m.p.h.; it is clearly quite different in character from that observed at normal speeds. At these enormous speeds the surface layers of copper have approached the molten state and have formed a thin layer of copper which is acting as a lubricant in much the same way that ski melt a layer of water on ice. The viscosity of molten copper is of the same order of magnitude as that of water. As soon as the rubbing surface is removed the copper solidifies to form a comparatively smooth shiny surface. Clear evidence of surface melting was found with a lower melting metal such as bismuth (melting point, 271 deg. Cent.). Fig. 12*d* shows a portion of the edge of the wear track. The solidified drops of molten metal may be clearly seen.



The friction falls from $\mu=5$ at low speeds to $\mu=0{\cdot}2$ at 1500 m.p.h.

Fig. 11—Metallic friction at very high speeds

These results are, of course, only preliminary since they were obtained no more than a few weeks ago, but they do lead to two interesting conclusions—first, that the frictional resistance to the sliding of metals at these very high speeds can be much less than at normal speeds, and also that the wear per unit of distance slid can be very much less. Perhaps the technical problem involved in sliding metals at these enormous speeds may not be so grave. If only one could move fast enough one might perhaps ski on copper mountains !

Friction and Mechanical Properties of Solids at Very High Temperatures

There is available at the present time comparatively little knowledge of the frictional properties (or, indeed, of the ordinary mechanical properties) of solids at very high temperatures. Comparatively few studies have been made at temperatures over 1000 deg. Cent. We have recently endeavoured to extend this range up to temperatures of 2000 deg. to 3000 deg. Cent. The behaviour of solids at these temperatures is of some interest both from the theoretical and the practical standpoint. Dr. G. W. Rowe has recently constructed an apparatus in which it is possible to measure the shear strength, tensile strength, hardness, friction, and other physical properties of solids up to 3000 deg. Cent. This is, of course, subject to the provision that they still exist at this temperature.

The work is still in a very early stage, but some preliminary friction results have recently been obtained with graphite. It is found, as is now well known, that the room temperature friction of outgassed graphite is several times higher than that recorded for graphite in atmosphere. This new apparatus has made it possible not only to heat graphite to a high temperature *in vacuo*, but also to make the measurements of friction actually at these temperatures. When this is done it is found that the friction of outgassed graphite falls fairly steadily as the temperature is increased. Fig. 13 shows that at 2000 deg. Cent. it has fallen to about one-half of its value at room temperature. This is in marked contrast to the behaviour of a kindred lamellar crystal, molybdenum disulphide (Fig. 13). The sharp rise at 800 deg. to 900 deg. Cent. is attributable to decomposition of the sulphide, producing a very high friction normally associated with clean metals. The reason for the decrease in the friction of graphite is not yet certain and further work is necessary, but it may be associated with the weakening of the van de Waal forces at high temperatures and easier orientation under sliding.

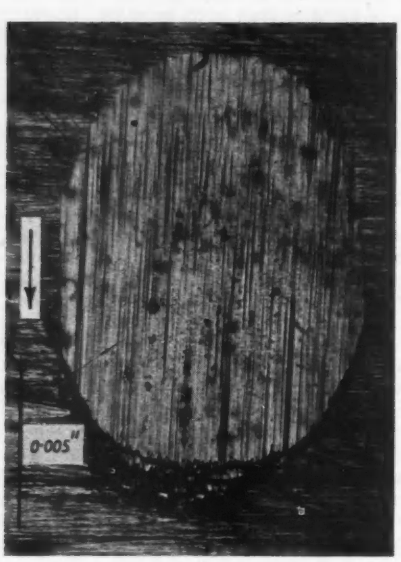
Rolling Friction

Up till now I have considered the friction which arises when one surface slides over another. There is, however, a different way in which surfaces can move over one another—that is, by rolling—and it is common experience that it is much easier to roll surfaces along than to slide them. The coefficient of rolling friction is perhaps less than 0·001.

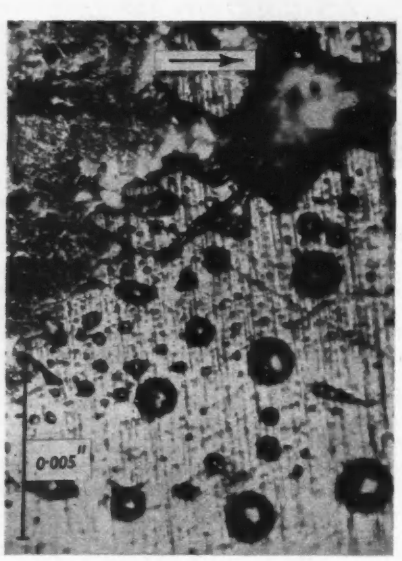
The source of " free " rolling friction has long been a matter of speculation. The first basic study was by Osborne Reynolds in 1875. He showed that when a metal cylinder rolls over a rubber surface it moves forward a distance less than its circumference in each revolution of the cylinder. This was associated with slip between the roller and the

a Slow-speed sliding wear on copper; 3ft per sec.; normal abrasion.

b Medium-speed sliding wear on copper; 500 m.p.h.; flow of metal.



c High-speed sliding wear on copper, melting point 1083 deg. Cent.; 1200 m.p.h.; surface flow.



d High-speed sliding wear on bismuth, melting point 271 deg. Cent.; 800 m.p.h.; molten droplets of metal.

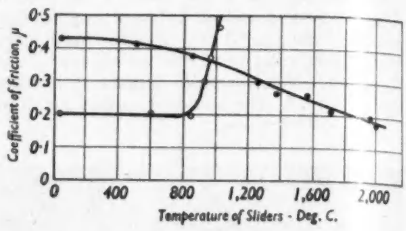
The arrows indicate the direction of sliding.

Fig. 12—Sliding wear

rubber and it was considered that the minute slip occurring was responsible for the rolling resistance.

Recently, Dr. D. Tabor has made an experimental study of rolling friction and has suggested another mechanism which is quite different from this (Tabor, 1954). He repeated Reynold's experiment and confirmed the first observation. If a metal cylinder is pressed deeply into a rubber surface it is found that in one revolution it travels forward a distance that is 10 per cent less than the circumference of the cylinder. The extent to which this involves slip between the cylinder and the rubber was examined in a very simple way. A small diametral hole, about 1mm in diameter, was drilled through the cylinder and its edges painted with printer's ink so as to make an impression on the rubber. Under light static loading a clear circular impression was made (Fig. 14). Under heavy loading during rolling a clear elliptical imprint was formed in which the minor axis was 10 per cent less than the major axis. According to Reynolds the stretching of the rubber involves interfacial slip and is responsible for the frictional losses. It is clear, however, from the clarity of the elliptical imprint that the interfacial slip is negligible. The cylinder simply measures out its periphery on rubber that has been stretched by 10 per cent and any interfacial slip is so small as to be totally inadequate to account for the observed frictional losses. Tabor's work has shown that the rolling resistance arises primarily from elastic-hysteresis losses in the rubber and this accounts for the observation that the rolling friction is scarcely affected by the presence of lubricant films.

When a hard steel ball rolls in a groove there is another source of slip which is of far greater importance than the Reynolds slip. This arises from the fact that the central band *AB* (Fig. 15) measures out its full circumference in a single revolution, whereas the bands *CD* at the edge of the groove measure out a smaller circumference. Consequently, some slip must presumably occur within the ellipse of contact, and Heathcote (1920–21), who first pointed out this effect, attributed the major part of the rolling resistance to this differential slip. Experiments with balls rolling in rubber grooves show, however, that differential slip of this type occurs only when the groove



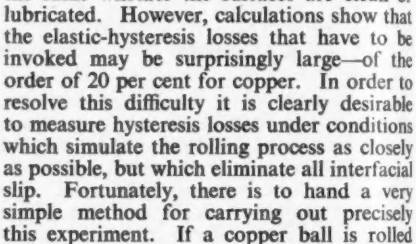
In both instances sliding occurred in high vacuum; the graphite had been initially outgassed at 2000 deg. Cent. and the molybdenum disulphide at 800 deg. Cent. At about 900 deg. Cent. molybdenum disulphide decomposes *in vacuo*.
• Graphite.
o Molybdenum disulphide.

Fig. 13—Variation in the friction of graphite and molybdenum disulphide with temperature

is exceptionally deep so that the ball is immersed almost to its diameter. For shallower grooves the Heathcote effect is trivial and again the main losses are due to elastic-hysteresis losses in the rubber.

In attempting to apply these results to the rolling of a steel ball in a metal groove it is at once evident that the hysteresis-loss mechanism explains the experimental observation that the rolling friction is essentially the same whether the surfaces are clean or lubricated. However, calculations show that the elastic-hysteresis losses that have to be invoked may be surprisingly large—of the order of 20 per cent for copper. In order to resolve this difficulty it is clearly desirable to measure hysteresis losses under conditions which simulate the rolling process as closely as possible, but which eliminate all interfacial slip. Fortunately, there is to hand a very simple method for carrying out precisely this experiment. If a copper ball is rolled over an identical copper ball the region of contact is, by symmetry, plane, so that the Heathcote slip is eliminated. Again, stretching of the interfacial elements will be the same on both balls, so that no slip of the Reynolds type will occur. Tabor's experiments along these lines show that the rolling resistance of a copper ball on an identical copper ball is independent of the presence of lubricants; is about as great as the rolling resistance of a hard steel ball in a copper groove, and involves elastic-hysteresis losses which may be as great as 20 per cent.

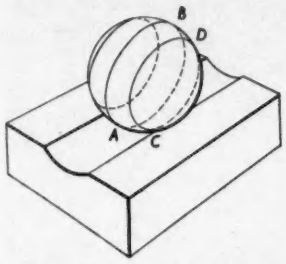
It is clear from these results that rolling



The ellipse has a minor axis 10 per cent less than the major axis, showing that the roller measures out its periphery on rubber which has been stretched by 10 per cent. The sharpness of the elliptic imprint shows that interfacial slip is negligibly small.

Fig. 14—Imprint formed for light static loading (circle) and for rolling under heavy load (ellipse)

friction does not generally arise from interfacial slip. Thus lubricant films may play an important part in reducing surface attrition or wear, but they have little effect on the rolling resistance itself. It would indeed seem that the rolling process involves little friction in the conventional sense. The



For each revolution of ball, central band measures out length $\pi.AB$, edge band measures out length $\pi.CD$, so that some slip must occur.

Fig. 15—Rolling of Ball in Groove

new point is that the major part of the rolling resistance arises from hysteresis losses within the metals themselves.

In real ball bearings and roller bearings the behaviour is complicated by friction of the cage and other factors, but it is clear that the hysteresis losses must play a very important part. They are closely associated with the fatigue life of bearings and this work may have practical applications in the search for improved bearings.

Conclusion

We have seen that the friction which is normally observed between sliding solids is due to the localised adhesion which occurs at the small regions of contact. With metals and with many solids complete adhesion is prevented only because the surfaces are contaminated by traces of adsorbed oxygen or other gases. If they are taken off in a vacuum, strong adhesion occurs and the friction rises to an enormous value. It is, therefore, a curious accident that solids on the earth's surface have the friction to which we are accustomed. The coefficient of friction for most ordinary solids lies between 0·3 and 1. If it were not for the contamination we should find the world a very sticky place to live in and much of our machinery would not move at all. Equally, if the friction were much lower than it is the ordinary conduct of our lives would be impossible. It is interesting to speculate on how different evolution would have been if the coefficient of friction on the earth's surface had been a little different.

In engineering practice, it is not so much the work which has to be done in overcoming friction—the power loss—which is important. In a modern car, for example, about 20 per cent of the power is wasted in overcoming friction. In an aeroplane piston engine it is about 9 per cent, and in a modern turbo-jet engine it is about 1½ to 2 per cent. The real trouble is the damage that is done by friction—the wear or seizure of some vital part of the machine. It is this factor, perhaps more than any other, which limits the design and which shortens the effective working life of a machine. Much ingenuity has been devoted to this problem and, up to a point, it has been successful—but only up to a point. It is difficult at present to run bearings which are hotter than 300 deg. Cent. The engineer would like to run bearings and to slide surfaces at 1000 deg. Cent. and at very high speeds, so unconventional surfaces and lubricants must be developed. A fuller understanding of the physics of the sliding process under these extreme conditions will help to do this.

Natural Draught Cooling Towers

By K. H. KHALIL, B.Eng., M.Eng., Ph.D., A.M.I.Mech.E.*

In cooling towers subjected to horizontal wind, an upward draught is created due to the narrow gap left at the bottom and due to variation in wind velocity near the ground. Factors influencing the magnitude of this draught are mainly the difference in kinetic energy at the top and bottom edges, and entrance losses at the gap passage. These factors are studied in this article both experimentally and theoretically, and a discussion of results emphasises that there is only one optimum gap for each case giving a maximum upward draught. The tower shape suitable to this condition is also studied.

NOT very much has been written about natural draught cooling towers. Most of this material investigates the packing inside the tower and the heat equilibrium of both air and cooling water through evaporation, convection and radiation. But in natural draught towers affected by horizontal wind the shape and outer main dimensions necessary to the designer are still apparently not yet decided.

Cooling towers form important parts in many power stations and heavy industry factories situated away from rivers or adequate natural water sources and their performances affect the efficiency of such plants and their economical balance to a great extent.

Water to be cooled in the tower gives up its heat to the rising column of air mainly by evaporation of some of the water which saturates the air in the tower, taking its latent heat from the rest of the water, and partly by convection to air and radiation. Were the air in the tower stagnant, the process of cooling would come to a standstill as soon as the air was completely saturated. Practically, this air is renewed by removing saturated air from the top of the tower and replacing it by fresh air with lower relative humidity through openings at the bottom of the tower; thus this process necessitates having a continuous upward draught to improve the performance of the cooling tower. This upward draught can be obtained either by mechanical means, such as fans or by natural horizontal wind flowing normal to the tower.

Natural Upward Flow in Cooling Towers.—Natural upward draught in cooling towers

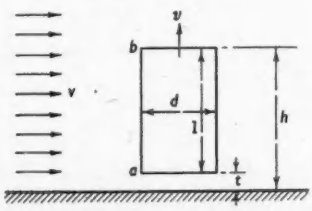


Fig. 1—Principle of upward draught caused by horizontal air flow

is generally due to: (*a*) thermodynamic effect or chimney effect; (*b*) aerodynamic effect due to natural wind flow.

Draught due to thermal effect can be treated similarly to the natural draught in a chimney, where it depends on the difference of temperature and consequently the density of the air inside and outside the tower. In this case the draught depends to a great extent on the height of the tower, in such a way that the higher is the tower the greater is the upward draught and the better is the performance. However, such towers must be compact and should be air-tight, as any leakage from the outside will affect the induced draught. Calculation of draught due to thermal effect can be performed easily, following experience in chimney design. Investigation in this paper will therefore be confined to wind effect producing upward draught.

Upward Draught Due to Wind Effect.—This effect is purely aerodynamic. A horizontal wind produces vertical upward or induced flow. The problem is thus similar to a cylinder placed in a wind tunnel with

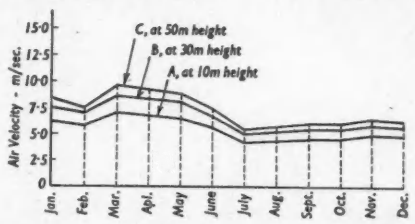


Fig. 2—Average wind velocity measured at Almaza Airport (Cairo) during the years 1941/1945

air flowing normal to its axis, as illustrated by Fig. 1, where d and l are the diameter and length of the cylinder, and:

t = the gap left clear from the ground.
h = the height of the tower = $l+t$.
v = horizontal wind velocity assumed uniform (at the beginning for simplicity).
u = average induced velocity or upward draught velocity.

From this arrangement it is clear that u is a function of the unbalanced pressure potential at both edges of the cylinder.

Considering total energy remaining constant in each section, kinetic energy at the ground edge "*a*" will be less than that at the top or free edge "*b*," with the result that there will be a difference in pressure causing the upward flow. However, the decrease in the kinetic energy at the bottom edge is due to entry losses of flow through the restricted passage. The value of the induced velocity u depends on the width of the gap t in the following way: when $t=0$ there will be no flow through the cylinder and $u=0$. But as t increases u increases also, until it reaches a limit where the unbalance of pressure at both edges of the cylinder begins to decrease again until it disappears completely and u becomes again equal to zero; this latter condition occurs when the gap is sufficiently wide for the flow past the two edges of the cylinder to be considered the same, and the effect of the ground plane becomes negligible. It thus follows that between these two extremes there is a value of the gap t which gives maximum induced velocity, and the correct choice of this gap width may be of great importance in getting the best results.

Effect of Wind Velocity.—To study the effect of wind velocity variation, actual sample figures of wind velocities have been obtained during a complete year and their variations with height above the ground noted.

Curve *A* in Fig. 2 represents average wind velocity measured at 10m height, and varia-

* Assistant Professor of Steam Power Engineering, Cairo University.

tions of wind velocity with the height follows Helmann's formulæ† :

$$V = K[1{\cdot}00 + 2{\cdot}81 \log_{10}(h + 4{\cdot}75)],$$

where

V is the velocity.
h is effective height.
K is a constant.

On the same figure curves B and C are drawn for heights of 30m and 50m, which represent heights of existing natural draught cooling towers in the Cairo area (Saptieh power station), to which we will refer later in this paper.

Fig. 3 gives the velocity gradient with the height for the maximum and minimum wind velocity during the year.

As there is a drop in velocity distribution near the ground level, there will be a natural

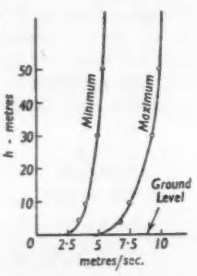


Fig. 3—Natural wind velocity at various heights. (Maximum and minimum in the year)

difference of head due to this effect, depending on the gap width t and the height h ; but if h is kept constant and the free edge of the tower remains in the region of flow of nearly uniform distribution, the unbalance of pressure decreases as the gap increases. This effect, however, will be discussed later in the work and verified by experiment.

In actual practice, the ground wind velocity sometimes falls to a very low value, due to the presence of buildings, and its magnitude can be neglected. Thus, the upward draught will be only dependent on the velocity of the free wind at the clear top of the tower, and on the resistance offered when entering the gap near the ground level and on the packing inside the tower.

Experimental Study on a Model Tower.—Experimental work was carried out on a small model of a cylindrical tower placed in a rectangular air duct at the end of an ordinary open jet wind tunnel. The working wind velocity in the tunnel at the rectangular section of 40cm by 47cm, just before the model, can be varied between 9m and 21m per second by changing the fan speed of rotation. The model was placed with its turning disc and baseplate on a bracket tied to the tunnel frame immediately outside the rectangular section mentioned above, in the free stream away from any wall effect, as shown in Fig. 4.

The cylinder model is made of steel 100mm outside diameter and 200mm high with 3mm uniform thickness. In the cylinder body there is embedded from the outside a small pressure tube, along the whole of its length. It is made of brass tube 2mm outside diameter and 1mm inside diameter. The tube was placed in a square groove milled in the cylinder, then covered by soldering tin and made flush with the cylinder surface.

One end of the tube was closed while the other was connected to the manometer for pressure reading. The tube was then drilled at four different levels from both sides of the cylinder at heights 25mm, 75mm, 125mm, 175mm, from the lower edge. While measuring at one level, the other holes are closed by adhesive transparent tape. The pressures can also be measured inside and outside the model by closing one side of the through hole and measuring from the other.

The model is supported by three screws on a 200mm disc fitted in a corresponding groove machined in the baseplate, so that it can be turned by a handle about the cylinder axis, to place the pressure tube in the desired angular position with respect to wind direction. By this arrangement it became possible to determine the pressure at different levels on the cylinder and at any angular position required, both inside and outside the model. The gap width of the tower can be varied by using the above-mentioned three screws and their locking nuts, as shown by Fig. 6.

Pressures were measured by an accurate inclined gauge, with variable slopes as shown in Fig. 5, and adapted with a vernier and a magnifying lens reading down to 1/1000 of a millimetre as required. A chock tube was used to assist in damping pressure oscillations in some of the regions. It was also found convenient to use alcohol as the medium in the gauge after colouring it red.

Experimental Results.—The velocity distribution in the tunnel was experimentally determined at one fan speed during all tests, as the curve in Fig. 7, measured by a standard pitot tube connected to the inclined gauge. The curve, however, represents a velocity gradient very near to that of natural wind above the ground.

The pressure distribution round the outside of the cylinder was measured and plotted in millimetres of water and compared with velocity head at one of the central holes near the mean height of the cylindrical model, as shown in Fig. 8. The changes in pressure distributions near the top and bottom edges occur mainly in the negative regions at the sides towards the back of the cylinder where the negative head is decreased.

Experiments also show that pressure distributions at the outside surface of the cylinder are almost independent of the gap width. On the contrary, pressures inside the cylinder vary with the gap and the level at which they are measured.

Fig. 9 represents pressure distribution measured in millimetres of water inside the model tower at tappings near the top and bottom edges and at one central point (125mm from top). Curves for one gap width of 6mm only are given here to illustrate the procedure. It is observed that pressures

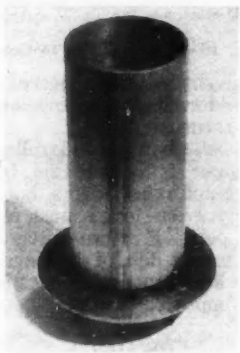


Fig. 6—Model tower mounted on baseplate

are negative with little variations at the different angular positions in spite of the enlarged scale in the drawing. It was therefore possible to consider one average pressure for each height to form a satisfactory basis for comparison.

Pressure distributions inside the cylinder were therefore repeated using several other gap widths and the average in each case was obtained and plotted against the corresponding gap, as shown in Fig. 10.

As mentioned before, the upward draught is based on the pressure difference between the edges and the greater is the difference, the higher is the value of the draught. But although this difference is rather small yet it shows a maximum value when plotted against the gap as shown in Fig. 11, which indicates that the maximum occurs at 6mm gap.

Average Induced Velocity.—If we consider the flow inside the cylinder towards its top edge adiabatic, then according to Bernoulli :

† *The Observer's Hand Book*, Meteorological Office, London.

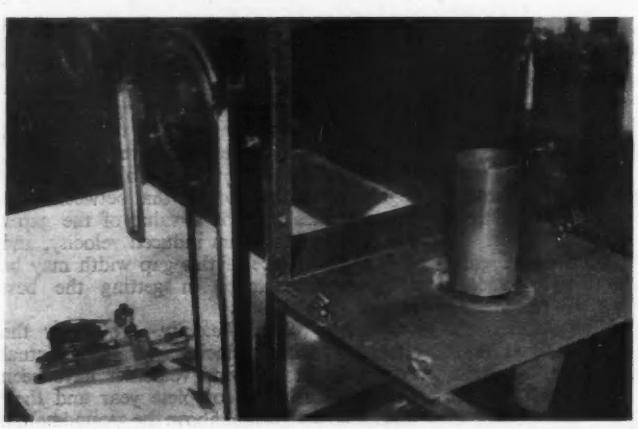


Fig. 4—Arrangement of model of cooling tower for wind tunnel test

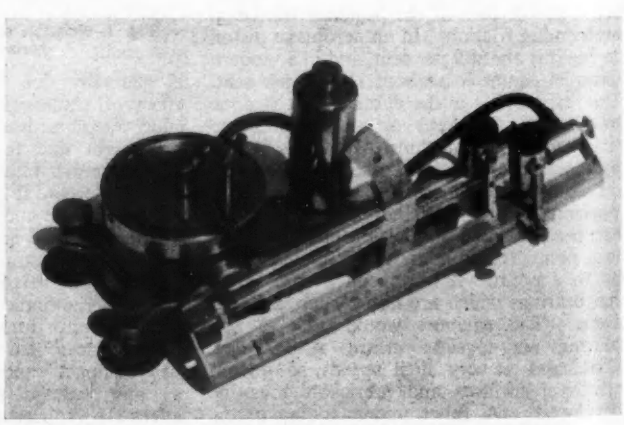


Fig. 5—Pressure gauge for wind tunnel tests on model cooling tower

Elementary change in pressure energy $=\rho U dU$ where

U is axial average velocity normal to wind direction.

ρ is average air density.

If U_0 at the bottom is considered zero as it is perpendicular to wind direction, then :

$$dP=\frac{\rho U^2}{2g}.$$

Where dP is pressure difference in millimetres of water.

Then

$$U \text{ in metre/second}=3\cdot99\sqrt{dP}.$$

At the gap of maximum draught (determined experimentally, Fig. 11) :

$dP=1\cdot38$mm and $U=4\cdot68$ m/sec.

Percentage of induced velocity to wind velocity is

$$\frac{4\cdot68}{15}=31\cdot2 \text{ per cent.}$$

From the curve of velocity distribution, Fig. 7 :

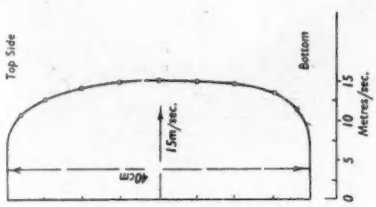


Fig. 7—Velocity distribution in wind tunnel

va (at the bottom edge for 6mm gap) $=11$m/sec.

vb (at top edge)$=15$m/sec.

Theoretical induced velocity

$$U=\sqrt{vb^2-va^2}$$
$$=\sqrt{15^2-11^2}=9\cdot7\text{m/sec.}$$

Coefficient of performance

$$=\frac{4\cdot68}{9\cdot7}=0\cdot483.$$

This loss of draught is due to resistance at the entrance of the gap and friction inside the cylinder, &c.

Theoretical Considerations.—The mathematical solution of this type of flow through the cooling tower is by no means an easy one owing to its complicated aerodynamic nature, and its three dimensional pattern and also due to separation taking place inside the cylinder. However, an attempt to simplify the problem aiming to find a simple solution to give the optimum gap with respect to the other dimensions is carried out here to connect theoretical and experimental methods.

Consider the case of a 50m high tower exposed to wind distribution such as that shown in Fig. 3, say at the highest value in March, to illustrate the procedure followed. The distribution of wind above the ground follows a logarithmic function which can be approximately formulated as $v=a\log(h+c)$ where a and c are constants, and h is the height from the ground level.

From the velocity distribution shown in Fig. 12*a* it is noted that the wind velocity at heights of 50m or more remains nearly the same.

The theoretical draught at any gap width is obtained by $\frac{(vm)^2}{2g}-\frac{v^2}{2g}$ where (vm) is the velocity at top edge equals maximum and v is velocity at the gap considered.

Accordingly, the upward draught ΔP in millimetres of water is plotted against the gap width in Fig. 12*a*, from which it is clear that ΔP is zero when the height at the gap is as big as 50m or when the draughts on both sides of the tower are balanced.

$$v=2\cdot46\log(h+7\cdot4)\text{m/sec.}$$

Height at gap in metres	v m/sec	v^2	Δv^2	ΔP in mm H_2O
0	4·9	24	75	4·71
10	7·1	50·2	48·8	3·05
20	8·2	67	32	2
30	8·95	80	19	1·18
40	9·5	90	9	0·56
50	9·95	99	0	0

The upward draught is, of course, affected by the restricted passage at entrance with the result that it equals zero when the gap t is zero, and rises quickly as t increases, according to a certain coefficient that governs the entrance resistance. Hence the theoretical draught needs to be multiplied by this coefficient in order to make it nearer to the actual value. Of course, there are other resistances to the flow, such as the packing, friction, &c., but they can be assumed to have a constant effect on the flow and to interfere little with the choice of the optimum gap. But the entrance resistance at the bottom of the gap varies greatly as the gap changes in such a way that the resistance coefficient starts as zero at no gap, then rises quickly, until a certain gap is reached, after which it should approach unity as the gap passage grows wide enough to offer theoretically less and less resistance.

This coefficient of entrance resistance could only be determined experimentally for any given tower as it depends on the nature of the passage entrance, smoothness of surface, velocity of flow and width of the gap, &c. However, it may be worth trying to estimate an expression for this coefficient resembling the actual performance. The conditions can be fulfilled by the hyperbolic equation :

$$C_r=\frac{t}{t+b}$$

where

C_r is coefficient of entrance resistance.

t is gap width and b is constant.

To evaluate the constant b, consider a case where C_r equals a high value of 0·9 at a reasonably wide gap of 5m (giving $b=0\cdot555$).

Fig. 12*b* has been drawn for values of C_r against gap widths in this case. For other cases b may take a smaller or bigger value as desired.

Theoretical upward draught

$$=\Delta P=\frac{vm^2}{2g}-\frac{v^2}{2g}$$

but

$$v=a\log(t+c),$$

where t is considered as the height at the gap.

Therefore theoretically,

$$\Delta P=\frac{vm^2}{2g}-\frac{a^2}{2g}\log^2(t+c).$$

Actual upward draught

$$\Delta P\times C_r=\Delta P\times\frac{t}{t+b}$$

or

$$\Delta P=\frac{v^2m}{2g}\times\frac{t}{t+b}-\frac{a^2}{2g}\cdot\frac{t}{(t+b)}\log^2(t+c).$$

The variables in this equation are t and ΔP. For maximum upward draught

$$\frac{d\Delta P}{dt}=0,$$

or

$$\frac{v^2m}{2g}\times\frac{t+b-t}{(t+b)^2}$$
$$=\frac{a^2}{2g}\frac{(t+b)\left[\frac{d}{dt}t\ .\ \log^2(t+c)\right]-t\log^2(t+c)}{(t+b)^2}$$

therefore

$$v^2m\times\frac{b}{a^2}$$
$$=(t+b)\left[2t\times\frac{\log(t+c)}{(t+c)}+\log^2(t+c)\right]-t\log^2(t+c)$$
$$=2t^2\frac{\log(t+c)}{(t+c)}+t\log^2(t+c)+2bt\frac{\log(t+c)}{t+c}$$
$$+b\log^2(t+c)-t\log^2(t+c)$$
$$v^2m\frac{b}{a^2}=2t\frac{(t+b)}{t+c}\log(t+c)+b\log^2(t+c).$$

This gives the condition for the gap of maximum draught, when substituting for

$vm=9\cdot95$m/sec $\quad a=2\cdot46$

$b=0\cdot555$ and $c=7\cdot4$.

Hence for the above conditions the gap that fulfils maximum upward draught is $t=3\cdot4$m for 50m tower and maximum wind velocity of 9·95m per second.

Fig. 12*a* also shows how the entrance resistance affects the draught at the smaller

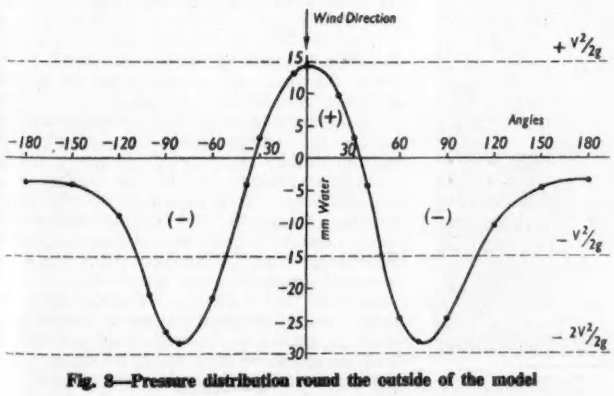


Fig. 8—Pressure distribution round the outside of the model

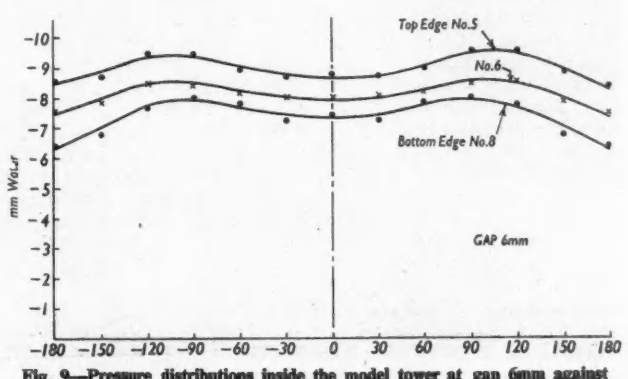


Fig. 9—Pressure distributions inside the model tower at gap 6mm against angular positions with wind direction

gaps, till a maximum is reached at the optimum gap.

Cooling Tower Diameter.—Knowing the gap dimension and velocity of stream before entering the suitable diameter of the tower can then be calculated if we consider that air entering the tower through the gap should continue passing upward with the calculated average induced velocity, after making allowance for frictional and packing resistances and leakage.

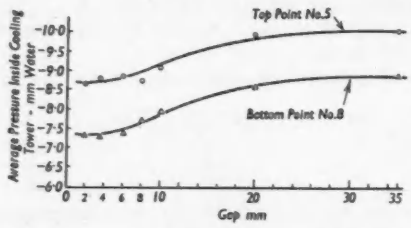


Fig. 10—Pressure distribution within model for various gap widths

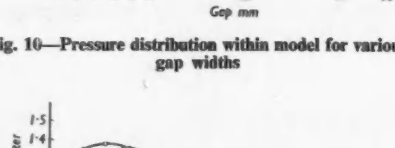


Fig. 11—Pressure difference between top and bottom for various gap widths

As the induced velocity in the vertical direction starts at its minimum (theoretically zero) at the bottom and reaches a maximum at the top after acceleration, the cross-sectional area at the top should be less than the average calculated area and at the bottom the area should be bigger than the average. The entrance should be made gradual to make easy the change from the horizontal wind direction to the vertical induced flow. If the gap is chosen bigger than the optimum the draught will be smaller, which means that a bigger tower diameter will be needed for the same height ; also a considerable proportion of the air will escape by passing straight forward through the gap without diversion into the tower. On the other hand, if the gap is too small the flow entering the tower will be throttled and the draught and quantity of air passing will be drastically reduced.

Sometimes designers are compelled to erect cooling towers in the centre of towns within factory buildings and houses. In such cases the tower ought to be higher than any building in the whole area, so that its top will be exposed to free wind of high velocity. It follows from the previous discussion that the optimum gap in this case will be greater, but the draught will be stronger.

Factors Affecting the Shape of the Tower.—Usually big towers of chimney type are made of reinforced concrete in various shapes, such as cylindrical, conical, or hyperbolic. Although round sections may be more suitable for wind with variable direction, yet a few rectangular towers do exist and work quite satisfactorily. From the aerodynamic point of view the conical and hyperbolic are better than cylindrical for the following reasons :—

Entering flow direction is changed gradually and rather smoothly from horizontal to vertical.

Separation behind the upstream side of the tower is very much minimised.

The cross-sectional area at the bottom, being comparatively large, allows a smaller gap width for the same entrance area and less resistance.

The bigger area at the bottom end allows the use of more packing with increased wetted area.

The increase in induced velocity towards the top necessitates the use of bigger cross-sectional areas at the bottom and smaller at the top with gradual change between.

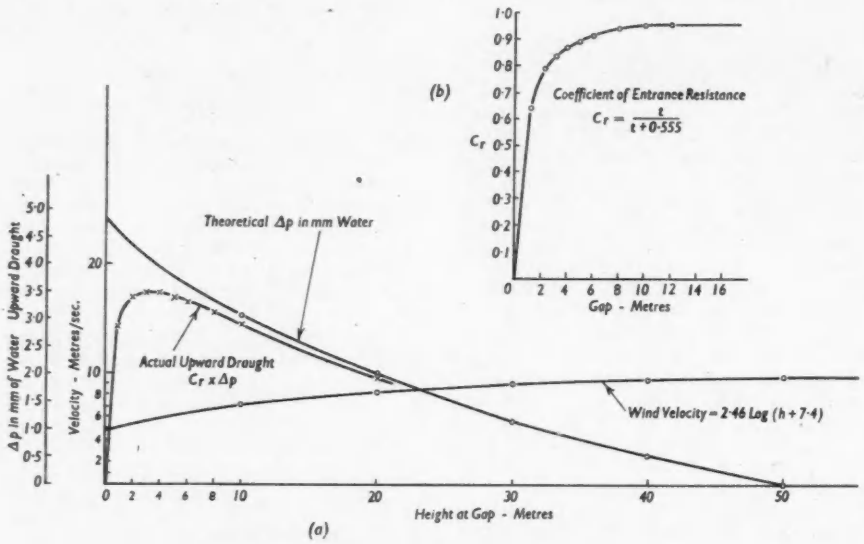


Fig. 12

If the cylindrical form is chosen for its simplicity in construction, inclined wooden boards are to be constructed surrounding its gap area, in order to help the gradual change of flow direction at the entrance. The gap should also be made comparatively higher.

The hyperbolic tower is still aerodynamically better than the conical, as it directs the entering air smoothly towards the centre of the tower and its upper rim tends to produce stronger upward draught rather than the inclined straight rim of the conical. The somewhat enlarged top of the tower also allows water to fall out of suspension. From the strength point of view, it has the advantage of eliminating the shearing stresses and the facility that straight boards can be used in its construction.

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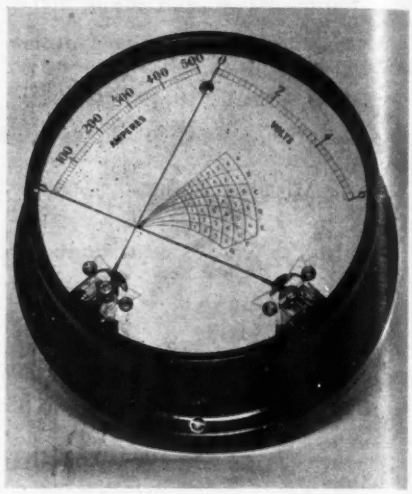
Electroplating Control Indicator

THE accompanying illustration shows a "cross pointer" electroplating indicator which has been developed by Measuring Instruments (Pullin), Ltd., Winchester Street, Acton, London, W.3. This instrument consists of an ammeter and voltmeter housed in a common case to facilitate the reading of plating vat current and voltage on the usual amperes and volts scales. In addition, the centre of the dial is marked with a special scale such that the intersection of the pointers gives an indication of the vat loading and current density.

It will be seen that this scale is made up of a number of arcs with a common origin formed by the intersection of the pointers when each indicates "zero."



Electroplating control indicator. The instrument houses an ammeter and a voltmeter, scaled so that the intersection of the two pointers shows the vat loading

The arcs are calculated and engraved so that, for a given resistance of the external circuit to which the instrument is connected, the pointers will always cross within the same zone (*A*, *B*, *C* . . . *G*) irrespective of the applied voltage. Each of the zones *A* to *G* is divided into a number of areas (1 to 6) by a series of concentric arcs which are equally spaced, to an arbitrary scale.

Briefly, the operation of the equipment is as follows. For production runs the vat is set up for the first batch of a run in the usual way. This operation determines the amount of work to be loaded in each batch, and the current and time necessary to produce the required thickness of plating. A note is taken of the area in which the pointers cross (for example, *D*6).

For subsequent batches the operator loads the vat until the pointers cross in the same zone—that is, *D*. This condition indicates that the vat resistance is the same as on the preliminary batch. As, for a given solution strength, this resistance is inversely proportional to the area of work in the vat, the setting therefore ensures that the correct amount of work is loaded. The operator then adjusts the current regulator ; both pointers will move and the crossing point will alter. However, as the load resistance remains constant the pointers will always cross in the same zone, and the adjustment is continued until the pointers cross in the correct area (*D*6 in this instance), indicating that the correct operating point has been reached.

Thus, once the vat has been set up for the first batch by the foreman plater, the plating control indicator enables an unskilled operator to repeat the same conditions for all other batches on a production run. It is suggested that for short runs and "one-off" batches an experienced plating operator can use the cross-pointer indicator to augment his own skill. Knowing the solution strength he can use the indicator as a guide to the load in the vat on the lines described above. After loading, the chart will enable him to set the current quickly and, if the pointers do not cross to the position which he expects from experience, this fact in itself gives indication of faulty vat resistance.

Modern Temper Mill Drive

A control scheme is described here for maintaining strip tension in a new 21in, single-stand, four-high, temper mill, at the Courtybella Works of the Whitehead Iron and Steel Company, Ltd. Control of this mill is exercised through a Ward Leonard system operating in conjunction with control exciters.

A NEW 21in single-stand, four-high temper mill has recently been commissioned at the Courtybella Works of the Whitehead Iron and Steel Company, Ltd. In this mill the coils of steel, previously cold-reduced to finished gauge, are subjected to a stage of skin passing. As the strip passes through the rolls the pressure and tensions are controlled to produce the required physical properties and surface finish.

To ensure uniformity in the finished product, the required tensions must be maintained throughout the temper rolling process, including the periods of acceleration and deceleration of the mill, and must not be affected by the changing diameters of the coils as the strip is unwound and reeled. The essential requirements of a satisfactory control scheme for a temper mill are, therefore, rapid response together with adequate sensitivity and stability. To meet these requirements the mill is controlled by a Ward Leonard system operating in conjunction with control exciters. The temper mill itself was supplied by the Davy and United Engineering Company, Ltd., and the electrical plant and control gear by The General Electric Company, Ltd.

A general view of the mill from the entry side is shown in Fig. 1. The uncoiler in the foreground is coupled through gearing to a drag generator rated at 50kW, 0/350/350V, 0/300/950 r.p.m. and the mill rolls are driven through reduction gears by a d.c. motor rated at 0/200/200 h.p., 0/250V, 0/300/750 r.p.m. On the delivery side of the mill (Fig. 2), the coiler shown on the left is driven through reduction gearing by a d.c. motor of 0/150/150 h.p., 0/350/350V, 0/300/750 r.p.m., which is equipped with an electro-magnetic brake. The motors are fitted with oil-ring-lubricated pedestal journal bearings and the drag generator with end-shield ball and roller bearings. All three machines are forced-ventilated with cooling air supplied by a 27in diameter fan driven by a 5 h.p. motor. Direct current for the mill drives is obtained from a motor generator set installed in a substation adjoining the mill. The set comprises a 435 h.p., 6kV slipring induction motor running at 970 r.p.m., direct-coupled to a d.c. generator with an output of 0/300kW at 0/250V. A totally-enclosed liquid starter is provided.

For the control of the mill drives there are three smaller motor-generator sets. The first consists of a 70 h.p., 1450 r.p.m. squirrel cage motor driving a 37kW delivery reel booster, a 20kW entry reel booster and a 9·5kW constant-voltage exciter ; and the remaining two sets are groups of four control exciters driven at 2900 r.p.m. by 6 h.p. motors. The three sets are mounted in the substation next to the low voltage switchboard, Fig. 3. Control cabinets are fitted to the entry and delivery sides of the mill. Both cabinets are equipped with drive selector switches, " inch " controllers, emergency stop buttons and indicator lamps ; in addition the delivery cabinet is fitted with a five-position " run " controller as well as selector and controller switches for the mill screwdown drives.

The Control Scheme

The G.E.C. control exciter which forms the basis of the control scheme for the mill is fundamentally a standard d.c. generator with conventional armature windings and brushgear. It differs from the standard machine in that its magnetic circuit is completely laminated, and that separate field windings are provided for the various control and stability circuits. In this application the control exciters, in addition to meeting the essential requirements already outlined, provide a control scheme which enables coils of a wide range of widths and thicknesses to be processed.

A simplified schematic diagram of the control scheme is shown in Fig. 4. It will be seen that the drag generator *G*4 and reel motor *M*2, and their respective boosters *G*2 and *G*3, are each excited by two control exciters connected in cascade. The power supply for *G*4, *M*2 and the main mill motor *M*1 is obtained from the generator *G*1 of the main m.g. set. The various control sequences are initiated by adjusting the voltages applied to the field windings of the motors, generator and exciters, the field supplies being obtained from the constant voltage exciter *CVE*. Overall speed control of the mill during acceleration is achieved first by increasing the field and therefore the output voltage of the main generator *G*1, and subsequently by weakening the field of the mill motor *M*1. The reverse procedure is followed during deceleration, while to stop the mill three forms of braking are provided. In normal use a regenerative scheme is used in conjunction with friction braking; for emergency stops dynamic braking is used.

To maintain constant tension in the strip as it is " paid off " the entry reel and " built up " on the delivery reel, it is necessary, for any given constant speed of strip or speed of *M*1, to keep the outputs of both *M*2 and *G*4 constant. This condition means that both the current flowing and the voltage generated in each reel motor armature must be kept constant. In addition, when the strip speed varies during acceleration and deceleration, the voltage generated in each armature must vary in direct proportion to the strip speed. The control exciters *PE*2 and *ME*2 keep the voltage generated in the armature of *G*4 constant irrespective of its speed for a given strip speed, and proportional to the strip speed when this speed varies. The control exciters *PE*4 and *ME*4 perform the same function for *M*2. The exciters *PE*1, *ME*1, control the field of booster *G*2 to keep the current in *G*4 constant, and exciters *PE*3, *ME*3, control the

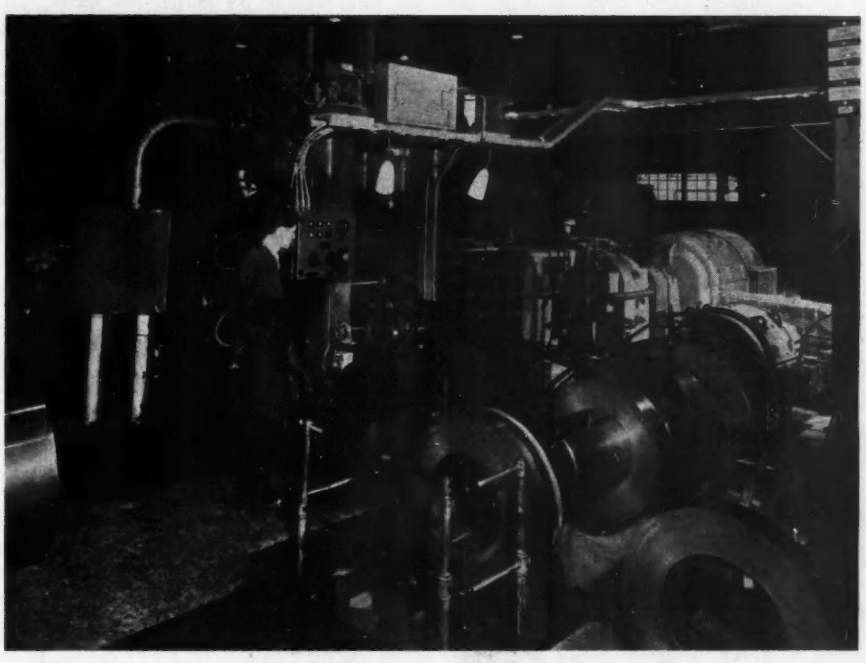


Fig. 1—Entry side of twenty-one inch temper mill at Courtybella works of Whitehead Iron and Steel Co., Ltd. The 200 h.p. mill motor and 50kW drag generator can be seen

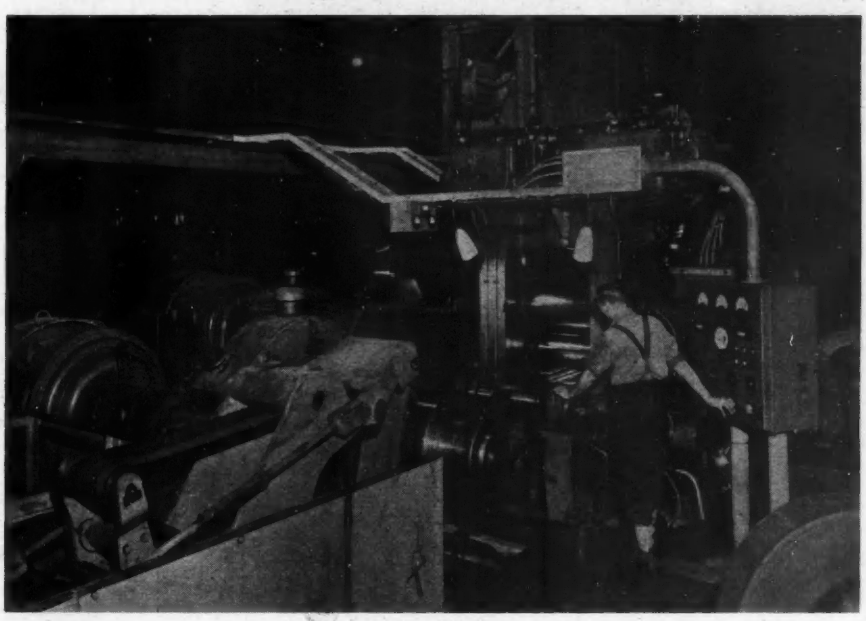


Fig. 2—Delivery side of Courtybella works temper mill. The 150 h.p. coiler motor and its main control cabinet can be seen

field of *G3* to keep the current in *M2* constant.

Delivery End Control.—The tension reference winding *A3* on pilot exciter *PE3* is energised from the constant voltage busbars through the delivery reel tension setter *R9*, which is mounted on the delivery control cabinet. This winding builds up the excitation and output of booster *G3* until winding *A3* is almost balanced by winding *D3*, which is energised from the commutating poles of motor *M2* and therefore produces an effect proportional to the motor current. Therefore, this current and hence the strip tension is controlled by the field *A3*.

The speed of reel motor *M2* is dictated by the strip speed or the speed of mill motor *M1*, and by the diameter of the coil on the reel. The reel motor must slow down with respect to *M1* as the strip builds up on the reel and, to keep constant the e.m.f. of the reel motor for a given strip speed or speed of *M1*, the motor field must be progressively strengthened by the associated control exciter set *PE4-ME4*.

This result is accomplished as follows. The reel motor *M2* is provided with two field windings, *Y4* and *X4*; *Y4* is sufficient to give the correct generated voltage in the reel motor armature when the motor is running at its maximum, or empty reel, speed, and the winding *X4* assists *Y4* to keep the generated voltage constant for a given constant strip speed as the speed of the reel motor decreases with coil build-up. The winding *X4* is connected in series with a rectifier, so that under no circumstances can it oppose *Y4* and cause overspeeding of the reel motor.

The field winding *X4* is controlled by the control exciters *ME4* and *PE4*. The winding *A4* of *PE4* is energised by the difference of two e.m.f.s; one is supplied by the tacho-generator *TG* driven by the mill motor *M1*, and is proportional to the desired strip speed, while the opposing e.m.f. is that generated in the reel motor armature. If the reel motor e.m.f. tends to be less than that of the tacho-generator, as

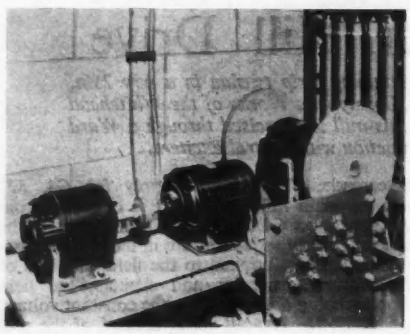


Fig. 5—Acceleration compensating motor with series booster and driving motor

when the motor slows down under coil build-up, the resultant voltage across *A4* increases and causes the exciters *PE4* and *ME4* to strengthen the field winding *X4* of the reel motor and restore its e.m.f. to the correct value to oppose the e.m.f. of the tacho-generator. The field winding *D4* on the exciter *PE4* is energised from the commutating pole winding of the reel motor and compensates for the resistance drop in the armature winding of the reel motor.

Acceleration Compensating Motor.—During acceleration the delivery reel motor *M2* requires increased current to provide the accelerating torque, as the strip tension would otherwise be reduced. Similarly, during deceleration, the stored energy of the reel and motor must be given up, because the strip tension would increase if the current were kept constant. Thus, it is necessary to provide excitation which increases the tension reference field *A3* during acceleration, and decreases it during deceleration. For this purpose winding *E3* is connected in series with an acceleration compensating motor *ACM* and a small series booster *SB* across the armature and commutating poles of delivery reel motor *M2*. Under steady conditions the motor *ACM* produces a back e.m.f. to balance the voltage across the reel motor *M2*, and takes only a small current to supply its rotational losses. The effect of this loss current on winding *E3* is neutralised by a slight preset adjustment of the tension reference field *A3*.

The acceleration of the motor *ACM* will be the same as that of the reel motor, since they are both proportional to the rate of change of voltage across the reel motor armature. The current taken by the motor *ACM* is proportional to the inertia of the flywheel and to its acceleration, and thus the current taken by *ACM* during acceleration is a measure of the acceleration of the reel motor armature. This current is used to energise the winding *E3* so as to assist the winding *A3*, thus automatically increasing the current setting by the amount required to accelerate the reel motor armature.

During deceleration the back e.m.f. of the motor *ACM* exceeds the voltage of the reel motor *M2*, and the current through *ACM* is reduced and eventually reverses, causing the flywheel to drive the motor *ACM* as a generator. The winding *E3* then acts in the reverse sense to oppose the winding *A3*, thus automatically reducing the current setting by the amount required to decelerate the reel motor armature. The series booster *SB* compensates for the *IR* drop in the circuit, and ensures that the back e.m.f. of the motor *ACM* accurately reflects the voltage generated by the reel motor *M2* at all times. The current in the motor *ACM*, and hence in the field *E3*, thus reflects the rate of change of speed of motor *M2*, and provides accurate compensation under changing speed.

In the event of strip breakage, the booster control attempts to maintain constant current in reel motor *M2*, and since this current is no longer providing tension, it tends to accelerate the reel to an excessive speed. To limit this

Fig. 3—Low-voltage switchboard for 21in temper mill drive

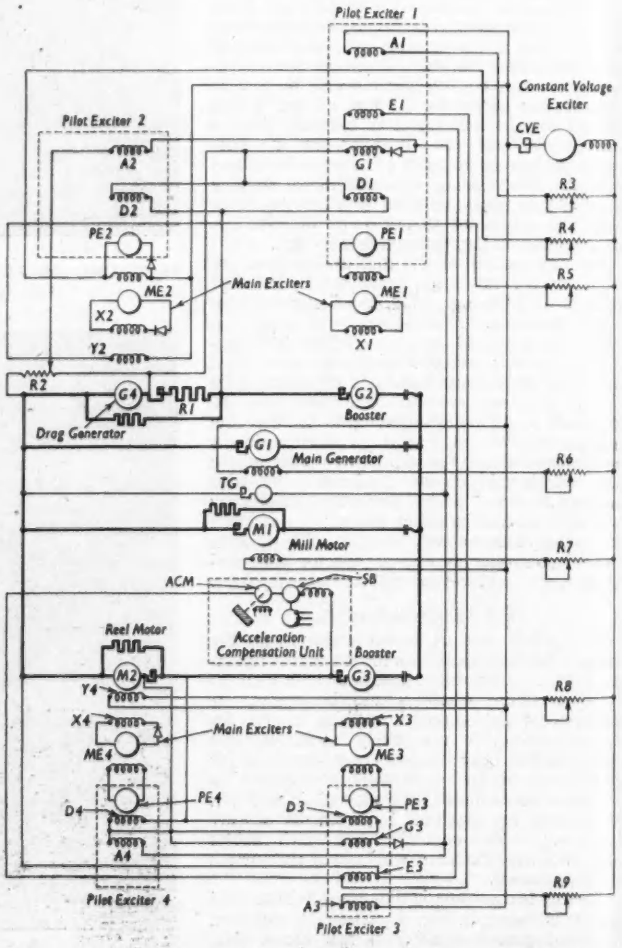


Fig. 4—Simplified schematic diagram of control exciter scheme for 21in temper mill drive

effect the winding *G*3 is arranged to oppose the tension setting field *A*3 when the e.m.f. of the reel motor appreciably exceeds the voltage of the tacho-generator, thus limiting the current which the booster will produce in the armature of the reel motor, and preventing any dangerous rise in speed. To prevent the winding *G*3 from carrying current when the e.m.f. of the reel motor is less than that of the tacho-generator, it is connected in series with a metal rectifier.

There are additional windings on the pilot exciters to correct any tendency to instability due to the sensitivity and rapid response of the exciters to sudden changes.

A stalled-tension switch is provided to enable a preselected value of tension to be maintained in the strip when the mill is stopped. This switch transfers the connections of the tension reference fields *A*1 and *A*3 of the exciters *PE*1 and *PE*3 from the running tension setters *R*3 and *R*9 to other setters which are adjusted to give the desired value of stalled tension. The fields of the exciters *ME*2 and *ME*4 are simultaneously connected to the constant voltage busbars via further stalled tension setters. The design of the control scheme ensures that stalled tension must be applied to the strip before rolling can be started.

Entry Tension Control.—The tension is controlled at the entry end, in a similar way to that described for the delivery end, by controlling both the current and the voltage generated by the drag generator *G*4. Both these quantities are kept constant for a given strip tension and strip speed, and the generated voltage is kept proportional to the strip speed when that varies. The control exciters *PE*2 and *ME*2 control the generated voltage of *G*4 and the control exciters *PE*1 and *ME*1 control the current by varying the field of the booster *G*2.

The main difference in the control is that whereas on the delivery side the field winding of *ME*4 is fed direct from the armature of *PE*4, on the entry side it is supplied from the constant voltage exciter via resistance *R*4 and this acting alone gives its maximum or full reel value. As the coil diminishes in diameter for a given strip speed, the speed, and consequently the e.m.f., of *G*4 tends to increase above that supplied by tacho-generator *TG*. The voltage excess is applied to the field winding *A*2 and causes the e.m.f. of *PE*2 to diminish and progressively divert current from the field winding of *ME*2, thus lowering and correcting the e.m.f. generated by *G*4. A metal rectifier in series with *PE*2 prevents over-excitation of the field winding of *ME*2. A metal rectifier is also connected in series with the winding *X*2 and prevents reversal of excitation which would cause an excessive current to flow in the armature of the drag generator. Another winding *D*2 on the exciter *PE*2 is connected across the resistor *R*1 and the commutating poles of the drag generator *G*4. This winding carries a current which is proportional to the drag generator current and compensates for the *IR* drop in the armature.

During acceleration, the drag generator must produce less current for a given strip tension, similarly during deceleration an increased current is needed to produce the decelerating torque. Consequently it is necessary to provide an excitation which opposes the field *A*1 during acceleration and assists it during deceleration, for this purpose the winding *E*1 is connected in parallel with the winding *E*3, but in the opposite sense. Compensation for change of speed is thus as already described for the delivery end.

In the event of strip breakage, the booster control attempts to maintain constant current in the drag generator, but this current is no longer produced by the torque resulting from the tension in the strip. The drag generator would therefore slow down and would eventually tend to run in the opposite direction, but it is prevented from doing so by the winding *G*1, which operates when the e.m.f. of the drag generator falls appreciably below the voltage of the tacho-generator *TG*. The winding *G*1 thus opposes the tension setting field *A*1, and limits to a safe value the current which the booster produces in the drag generator armature. A rectifier is included in the circuit to prevent the winding *G*1 from carrying current in normal operation, when the e.m.f. of the drag generator exceeds that of the tacho-generator.

Aviation and the Development of Remote Areas*

By H.R.H. THE DUKE OF EDINBURGH, K.G., K.T.

H.R.H. The Duke of Edinburgh discusses the use of aircraft for uses other than military or passenger carrying purposes, emphasising the special contribution they are making in the development of remote areas in the Commonwealth and Empire. Current examples of their application in agriculture, pest control, surveying, and special freight transport are given. It is maintained that this important aspect of aviation has been neglected by the aircraft manufacturers and that a class of aircraft specifically suited for these purposes should be developed.

DURING the recent tour of Australia and New Zealand and then later in Canada, I had a wonderful opportunity to hear about, and sometimes to see, the enormous variety of uses other than passenger carrying to which aircraft have been put in those countries. It is not perhaps surprising that they have found so many uses for aircraft, considering the conditions. Australia and Canada are enormous countries by any standard and although New Zealand is not much bigger than the British Isles, the population is about 2,500,000, compared with roughly 50,000,000 in these islands. The distances involved alone make aircraft the obvious choice for general transport. In this country all forms of aviation and transport are bedevilled by chancy weather, to say the least of it, while Australia, New Zealand and Canada are blessed with relatively good flying weather for most of the year. Services in Australia work to a 98 per cent regularity. On top of that the attitude to flying in those countries is quite different, it is part of their life and not in the least restricted to the relatively few people who go abroad regularly, as it is largely in this country.

Aircraft and the men who fly them occupy quite a special place in the minds and affections of the people who live in remote districts. For instance, the pilots of the aircraft engaged in the outback services in the Northern Territory of Australia are doing by air, with all the added difficulties, what the carriers and bus drivers are doing in the rural areas of this country. The pilots are required to service their aircraft, repair minor defects, refuel, collect fares, issue invoices for passengers and freight, and do the loading and unloading. In addition, they are expected to run to a strict schedule, navigate over poorly mapped areas which they must know well, land and take-off from a great variety of bush airfields under varying weather conditions. In fact, the pilots become well known to all the residents and become part of the life of the Territory, and the whole thing is accepted as being perfectly normal.

Many things are quite reasonably done by aircraft out there which would be the height of extravagance or folly in this country. In many cases, of course, aircraft are used, not because it is easier, quicker or cheaper, but simply because there is no other way at all.

Distances, weather and the absence of other facilities, therefore, make aviation a vital and integral part of the civilisation of those countries and no longer an interesting novelty or a convenience for the relatively few.

My first-hand knowledge of Africa and the Indian continent is rather more limited, but I imagine much the same applies there, or will do before very long, especially if the right kind of aircraft are forthcoming.

Aircraft and Agriculture.—Now, for a moment, I would like to get down to cases because it is only by quoting cases that I can try and show you the extraordinary range and importance of aviation in the Commonwealth.

To take agriculture first. Aircraft are being used for crop-dusting, which is really a form of pest control, for seeding, top-dressing and for the survey of land and in forestry. That is, of course, broadly speaking, because it would be almost as difficult to describe all the uses of aircraft in agriculture as to enumerate all the uses of a farm tractor.

Top-dressing is a speciality of New Zealand and the object of the exercise is to drop fertiliser on to otherwise inaccessible pasture land to improve the grass to feed sheep. It is important to remember that this is not an alternative way of doing it—it is the only way. Top-dressing is done by air or not at all. I do not think that there is any doubt about its usefulness. Let me give you some figures. On a 900-acre block in the Auckland district, with two seasons of top-dressing with 4 cwt to 6 cwt of phosphate and potash per acre, the capacity of the block has been increased from 1200 to 2300 ewes, and it is hoped to increase that to 3000 in the next two years. Throughout New Zealand there were twelve aircraft employed on top-dressing in 1939. That figure has now risen to 162. In 1953 they distributed 140,000 tons of fertiliser over 1,500,000 acres. Some people estimate that aerial top-dressing is capable of increasing meat production in New Zealand 50 per cent in ten years, and the ultimate target is to treat 10,000,000 acres of hill country.

To give some idea of the cost of this work it is estimated that counting fertiliser, transport, dropping, interest on capital, &c., it works out at between 30s. to 34s. per acre, or some £3 per ton dropped. The latest development is a product consisting of a hormone and a super-phosphate for the dual purpose of weed killing and fertilising.

Apart from top-dressing, aircraft are used to spread trace elements (this is done commercially in New Zealand for between 6d. and 1s. per acre), for sowing seeds, dropping fencing and other supplies, such as fodder and poison bait, and frost protection of valuable crops. In America it is estimated that aircraft used for agricultural purposes—and there are 7000 of them, compared with sixty-five in Western Europe—spend 55 per cent of their total flying time in pest and disease control, 35 per cent in seeding and fertilising, and 10 per cent in photographic survey for erosion, pest infestation and for planning irrigation works.

So far as aircraft for agriculture are concerned, particularly in spraying for pest and weed control, they have one important advantage, in that they avoid any mechanical injury to the crop, which would be unavoidable with ground machinery.

Whatever purpose aircraft are used for there is one fundamental rule: the aircraft must be employed all the year round to make it worth while. The whole difficulty of operating aircraft for agriculture lies in finding a variety of uses which will achieve this ideal.

Aircraft in Pest Control.—There are many sides to pest control from the air, but they are mostly alternatives to ground methods. In Africa, however, aircraft are used for locust control and in this case there is no alternative which is anything like so effective. For every pound spent on aerial spraying of locusts crops up to the value of £110 can be saved. In 1954 a battle was fought in East Africa by ten light aircraft, operating from a 600-mile line of bases in Kenya and Tanganyika, against an invasion by some fifty swarms with a total area of about 500 square miles and containing something like 50,000 million locusts weighing perhaps 100,000 tons. This time the locusts won, although many large swarms were attacked in flight and several were completely destroyed. During the battle it was found that 300,000 locusts can be killed by 1 gallon of poison sprayed from aircraft at a cost of £6 per million locusts killed.

Also in Africa, aircraft are used against what is probably the greatest obstacle to development of that continent. In Tanganyika alone 75 per cent of the total land is unsuited for settlement because of the tsetse fly. They could be wiped out from the air, but at present it takes three applications and that is still rather expensive.

Almost every country in the Commonwealth and Empire can provide examples of the use of aircraft in pest and disease control. Forests are surveyed to find infected areas and in Canada budworm in forests have been attacked with DDT with great effect.

The most important and effective way of controlling pests and diseases, if good husbandry and good sanitation prove inadequate, is by the use of poisonous chemicals. The immense development of potent new chemicals in recent years has meant that only from 1 to 25 gallons of spray per acre are required, where 100 to 3500 gallons would have been necessary a few years ago. In fact, the low dosages at which the

* Tenth British Commonwealth and Empire Lecture, Royal Aeronautical Society, December 16, 1954.

new chemicals are effective have been directly responsible for the increased use of aircraft for the control of pests and diseases in the past twelve years. The essential quality of aircraft which suits them for this work is their independence from the nature of the countryside, which enables them to reach standing crops, deserts for locusts, tree tops for forest pests and swamps breeding mosquitoes, that would be inaccessible to ground machines, and to treat such infested areas with a speed quite impossible by any other means.

Another method of dealing with pests is by biological control. This means spreading harmless insects which will live on the pests and reduce their numbers. This sort of thing can be done most efficiently by air, in fact it can also be done unintentionally, with harmful results. For instance, before starting the South Africa to Australia air service it was discovered that there were fifty-two varieties of pests which existed in South Africa, but not in Western Australia, which were liable to be transported inside or outside the aircraft on that route.

Aircraft for Freight.—For many years there was a tendency in this country to think of air freighting as rather expensive and unnecessary. This is not altogether surprising considering the difficulties of weather, short distances and, in the early days, the relative lack of funds available to the aviation industries. There are now, I am glad to say, many welcome signs of growing interest in the rapidly expanding market for air freight.

Development was very different in Canada, for example, where as early as 1937 Canadian aircraft carried 24,000,000 lb of freight, compared with 9,500,000 lb lifted by United States carriers in 1939.

Air freight opened the Canadian North in the 'twenties and 'thirties and every further development in that area depends entirely on aviation. Take, for instance, the Eldorado uranium mine at Port Radium on the Great Bear Lake, less than 30 miles south of the Arctic Circle. In the first place it was discovered by Gilbert Labine in 1930 from the air in an aircraft flown by C. H. " Punch " Dickens, a famous name among the bush pilots of Canada.

The mine at Port Radium is entirely supplied by air from Edmonton, 1200 miles away, except for particularly large or heavy equipment. The Eldorado Company also looks after another establishment at Beaverlodge, 350 miles from Edmonton. The company operates one Dakota and one Curtiss " Commando," which, between them, lift on the average 3000 passengers and about 3000 tons of freight every year. A total of roughly 2,500,000 ton-miles at a cost of 22½ cents per ton-mile. The only other transport system is by water, and although this is considerably cheaper—it costs 80 dollars for every ton taken to Port Radium, compared with 225 dollars per ton by air—navigation to Port Radium is only open for one month and to Beaverlodge for four months in the year. Therefore allowance must be made for the cost involved in carrying large inventories of waterborne freight and equipment. In fact, the water route is only used to bring out the products of the mine.

The figure of 22½ cents per ton-mile becomes rather more interesting when it is compared with the cost of road transport over comparable distances in Northern Canada, which is, at a rough estimate, about 15 cents per ton-mile, although the average for the whole of Canada is 5½ cents per ton-mile.

Two of the reasons why this company can operate at such a relatively low cost are that both aircraft were picked up cheaply as war disposal and because of the large back haul of passengers and concentrates which make for the high load factor of 90 per cent.

The important point here is that these establishments, thanks to aircraft, are in no way cut off from the outside world. Since fresh food and vegetables, newspapers and books can be flown in all the year round, the community, which includes several families, lives a normal full life.

Passing now from Canada to Australia, where an experiment has been running some six years on the flying of beef from a cattle station to the coastal port. These cattle stations can be up to 5,000,000 acres in extent and 500 miles from the nearest railhead or harbour.

The experiment was started by Air Beef, Ltd., who established an experimental abattoir at Glenroy, some 180 miles inland from Wyndham in the north-west corner of Western Australia, with a capacity for dealing with sixty head of cattle per day or 300 a week. During the six years an average of 4000 head of cattle per annum have been killed and the result has been to upgrade the meat from 23 per cent export quality to 65 per cent export quality, and total frozen carcass weight has gone up 13 per cent. Before the introduction of Air Beef only about 7 per cent of the cattle raised ever reached the meat works. Although the value of the meat has only gone up by 34s. a head, the increased production of meat has increased revenue by over 200 per cent. The number of cattle marketed from that station has doubled and the station has been enormously improved by the increased income and by using the aircraft to transport to the station all the equipment required for the development.

The possibilities for Australia are immense. It has been estimated that by using inland abattoirs and air freighting beef production in Australia could be doubled in ten years.

There is one other use for air freight which I would like to mention. It is in connection with the giant construction jobs in remote districts. Early this year a 350-mile railway from the St. Lawrence to Knob Lake on the border of Quebec and Labrador was completed to carry iron ore. This railway is capable of carrying trains weighing up to 10,000 tons. The railway was built principally by air. Using six landing strips, men, equipment and food were flown to work on various sections of the line. I have already mentioned that helicopters were used to survey the route for the power line from Kemano to Kitimat. I think it is worth mentioning here that the line was also built with the use of helicopters, which carried every man and piece of equipment to remote spots up to 5000ft above sea level.

Requirements

That really concludes my rather sketchy summary of what aircraft are used for in the Commonwealth and Empire.

There are several conclusions to be drawn. The first and most important is that, apart from the " Bristol Freighter " and the " Beaver," and later the " Otter," not one single aircraft used in any of the fields I have mentioned was actually designed for the job. Every sort and kind of aircraft are used from " Moths " to " Dakotas," and they are all old and were all designed for something else. It is like using a double-decker bus as a milk float, or a Bentley as a farm tractor.

It is also perhaps interesting to note that both the " Freighter " and the " Beaver " were private ventures, the latter being designed and built in Canada. I may be wrong, but so far as I know the only aircraft on the stocks which falls into the category I am discussing is the " Twin Pioneer "—known to some as the " Double Scotch." This started as, and is still, substantially a private venture ; it was designed and is being built by a company that has only produced one type of aircraft previous to this effort. I think it is worth remembering that when the " Beaver " was first mooted the makers went to considerable trouble to find out exactly what the bush pilots of Canada really wanted and throughout its development their opinions, experience and criticisms were sought and used. The result is an aircraft which they like and use : 113 " Beavers " and fifty-one " Otters " are in use in Canada already. Not unnaturally, these aircraft are in demand outside Canada also.

Several attempts are being made to produce a " DC-3 " replacement, notably the " Herald " in this country, but it is not an easy thing to do because the " DC-3 " will only be replaced by an aircraft which is better in all respects and, most important, considerably cheaper to operate.

The secret of success seems to be the very closest co-operation between the makers and the operators. That co-operation exists in development of air liners, it is not always present in the development of aircraft for the outback.

The *Civil Aviation Journal* of New Zealand introduced an article with these words : " While it is not usually the policy of the *Civil Aviation Journal* to reprint articles from other publications, this article is so apposite to a major problem of concern to operators in New Zealand that we have on this occasion departed from normal policy. Acknowledgement is made to the publishers of *Aviation Age* for permission to reproduce this article."

The *Journal* then prints an article called " We Want a Flying Tractor." I will not weary you with details, but the author wants an aircraft of 1 ton capacity, a biplane, low-wing loading, load and engine ahead of the pilot, no flaps or slots, simple, low speed and price.

In fact, an aircraft obviously based on these requirements has been built in America and is expected to cost between £5000 and £6000. Trials already indicate that, using this specially designed aircraft, the operating cost of chemical application is roughly half that of the cost of the best existing aircraft converted for the purpose. The other interesting fact is that a third of these aircraft to be built will probably be sold to New Zealand. I have also heard that more than one British aircraft company is giving careful attention to the needs of New Zealand's top-dressers and aerial agriculturists.

From Australia I would like to read an extract from a letter from the Operations Supervisor of Connellan Airways at Alice Springs, who, among other things, run the flying doctor service there.

" The one difficulty which is faced by bush airline operators is the lack of a suitable type of aircraft. At the moment there is no aircraft being manufactured, nor as far as is known is one even contemplated. Tough conditions are experienced and the aircraft must be designed for the job. Specifications for such an aircraft, the ' Brolga,' were published in the Australian *Aircraft* magazine in 1950 and were sent all over the world to manufacturers. A great service would be done to bush operators, not only here, but in other undeveloped parts of the world if this need could be presented to the aircraft manufacturers, for then it is possible that such a suitable aircraft could be produced."

From Canada, Eldorado Aviation have this to say : " We are now using aircraft which are approaching obsolescence. We must shortly consider replacement. At the present time there is no new aircraft available which meets our requirements. This is a problem which is common to all operators in Canada serving remote areas. Possibly the best commentary on the failure of the aircraft industry to meet this particular demand is the fact that ' DC-3 ' aircraft now command a higher price on the market than they did in 1946."

So far as the British aircraft industry is concerned, out of 687 aircraft of sixty-four different types employed on bush operations in Canada in 1953, only forty-six were built in this country and only four were built after the war.

Quite obviously this is only one side of the picture, and no one would deny that the makers have their troubles and difficulties, too. After all, even pilots and operators are not well known for being able to state and stick to their requirements, although they can be relied on to say with considerable emphasis what they do not want. But the fact remains that aircraft are needed for these operations, that aircraft will be used for these operations and somebody has got to make them.

There can be no doubt that aviation is an essential element in the development of the Commonwealth and Empire. Hence it follows that aircraft must be designed for the jobs for which they are required, or the aircraft must be highly versatile. That, whatever the job, the aircraft must be simple, robust and easy to maintain. That speed is a secondary consideration for the simple reason that even if they only flew at 30 knots they would still get to places several months before dog teams or ox carts. This does not mean that aircraft have got to be slow. If high speed makes them more economical to operate, so much the better.

Eventually, of course, in anything of this sort the question of relative cost creeps in and quite rightly. This applies equally to bush or outback operations as it does to the movement of heavy freight over long distances. The difficulty about estimating the cost of this type of aviation is that it is very difficult to find comparable figures. In Northern Canada the cost per ton-mile by air is not much greater than by road, but that

takes no account of the cost of the road in the first place or its maintenance. In Australia the railways, as in quite a number of countries, are run at a loss, yet quite obviously they must go on running.

The difficulty at the moment seems to be to estimate correctly exactly what type of operations are most suited to each system of transport. The conclusions, as I see it, are that the scope for aviation will be considerably broadened : first, when the full advantages and possibilities of aircraft are thoroughly appreciated and trusted by potential operators ; and secondly, if and when suitable aircraft make their appearance.

Although it is really outside the scope of this lecture, I must draw attention to the very great importance of a strong flexible air cargo fleet in the event of war. After all, it is the combination of the Navy and Merchant Navy which constitutes our maritime strength. Similarly, our power in the air depends upon the combination of the Air Forces and the Merchant Air Fleets of the Commonwealth.

At the moment the centre and head of the aviation industry for the Commonwealth and Empire is in these islands. It is true that great strides have been made in some of the Dominions in the design and production of aircraft suited to their own needs, but the industry in these islands is still the leading partner and capable of making many useful contributions for a number of years yet. If it is to do this it must not be blinded by the chances of lucrative Ministry of Supply contracts, or have its attention to the requirements of the Commonwealth and Empire distracted by the clamour of Britain's airline operators. The Ministry of Supply, the Service Ministries and the civil operators are obviously the industry's best customers and patrons, and they cannot be blamed for only considering their own special requirements. But if the industry is to play its proper part it must look beyond that and consider the progress of aviation as a whole and all over the world.

I have no intention of telling them how this can be done. All I wish to do is to draw attention to what I think has become a neglected part of aviation. What is more, it is that part of aviation which has the most important part to play in opening up the remote areas of the New World.

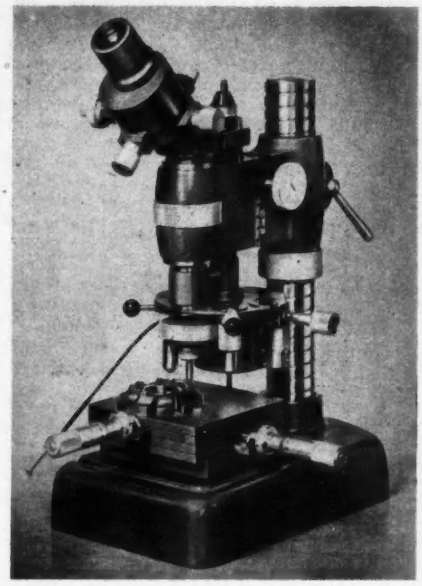
It rather looks as if I have placed all the burden of the future development of outback and bush aviation on the makers. That is not the impression I want to leave. It is much more important that each party concerned should understand and appreciate the demands, difficulties and limitations of the others and of aviation in remote areas in general.

Small Hardness Tester

THE illustration shows the " Durimet " hardness tester made by Ernst Leitz G.m.b.H., Wetzlar, Germany, and handled in this country by E. Leitz Instruments, Ltd., 20, Mortimer Street, London, W.1. This instrument is designed for Vickers, Knoop, and scratch hardness testing with loads ranging from 15gm to 500gm. It will be recalled that both the Vickers and Knoop hardness numbers are expressed in terms of load divided by the square of a characteristic dimension of the indentation. In the case of the Vickers test, one measures the diagonal of a square indentation ; the depth of the indentation is one-seventh of the diagonal. The Knoop diamond is a rhombic pyramid with diagonals in the ratio of 7 to 1, and angles of 172 deg. and 130 deg. between opposite edges ; the longer diagonal is measured, and the depth of the indentation is only about one-thirtieth of this length. The load chosen depends on the hardness of the material and on the nature of the test piece. The small loads used here are particularly suitable for thin specimens or where hardness values are required locally in certain parts of the structure or near an edge.

The instrument is mounted on a stand which is fitted with a compound stage for the test piece. Large test pieces can be placed behind the stand, the instrument being swung round to the rear. The indenting mechanism consists of a lever resting on a knife-edge and held in place by a leaf spring. Steel wires are used to attach the diamond holder to the longer arm of this lever, the arrangement preventing the diamond from being dragged sideways as the load is applied. Such dragging results in a distorted impression. The minimum load of 15gm is constituted by the dead weight of the lever ; higher loads are applied by adding calibrated weights.

The instrument is positioned with the help of a low power objective, and on pressing the release



Hardness tester with test piece on compound stage. Indenting mechanism and microscope objectives are interchanged by turning the revolver

wire shown, a spring-and-dashpot operated cam lowers the diamond and makes an impression. After raising the lever (and at the same time, rewinding the release spring), the revolver is turned to bring the high power objective into position. By means of a micrometer eyepiece, the indentation can be measured to 0·0005mm. The instrument is equipped with low-voltage vertical illumination. Scratch hardness tests are performed in a similar manner, the scratches being made by turning the front micrometer of the compound stage, after the diamond has been applied.

Optical Jig Borer

SIMPLICITY of measurement and accuracy are combined in the model " P325 " optical co-ordinate jig borer made by Henri Hauser, Ltd., Bienne, Switzerland. The machine, shown in Fig. 1, is intended for clock and instrument work and is suitable for drilling up to $\frac{1}{4}$in diameter and boring up to $\frac{5}{8}$in diameter. In addition, it can be equipped with scribing and punching devices. The work table has a longitudinal travel of 4in and the boring head a transverse movement of the same amount. Setting to co-ordinates is done by means of two completely protected master scales mounted at right angles which are read by means of the two measuring microscopes seen on the right and left. The scales are divided either into millimetres or multiples of 0·050in, as shown in Fig. 2. Eyepiece graticules with stepped diagonal scales, each step corresponding to 0·0001in, permit direct readings to 0·00005in to be taken. A centring microscope is used for setting to punch marks.

The boring spindle runs in precision ball and roller bearings and is fitted with a No. 0 Morse taper to take a drill chuck, boring tool or collets. It is powered by a $\frac{1}{5}$ h.p. motor, and may be driven by means of a variable-speed gear at any speed from 200 to 3000 r.p.m.

Additional equipment includes a 7in rotary table, which can be read to 10 seconds of arc. The stand which contains the electrical controls is open at the front to allow the operator to sit at

Fig. 1—The co-ordinate scales of this optical jig borer are read to 0·00005in by means of microscopes fitted with eyepiece scales. The objective of the centring microscope (on spindle head) can be swung in or out

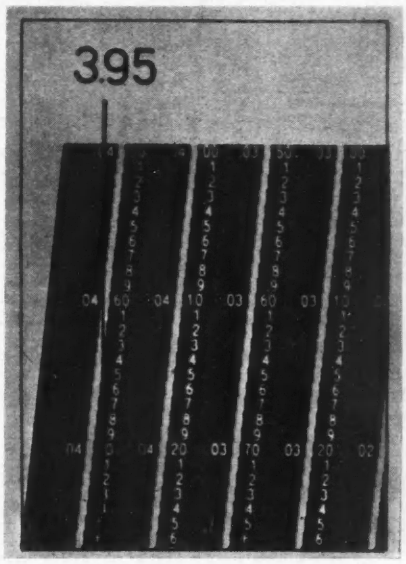


Fig. 2—Part of field of measuring microscope, showing 3·95in main scale division and diagonal eyepiece scales—reading ; 3·99615in

work ; an elbow rest is also provided. Agents in this country is Wickman, Ltd., P.O. Box 36, Fletchamstead Highway, Coventry.

TRANSLATION OF SCIENTIFIC MATERIAL.—In view of the constant demand for the speedy and accurate translation of scientific and industrial research material, Aslib is arranging a special meeting to pool existing knowledge of the ways in which such translations are being made and utilised. This meeting will be held on Monday, January 17th at 6 p.m., at the Royal Society of Arts, 8, John Adam Street, London, W.C.2. Mr. E. B. Uvarov, head of the technical information bureau of Courtaulds, Ltd., will preside.

A LUBRICATING OIL.—A new lubricating oil has been developed at the Sunbury research station of the British Petroleum Company, Ltd. It is claimed that because this oil—B.P. Special Energol Visco-Static Motor Oil—has a relatively small viscosity change with temperature, it ensures easier starting, reduces engine wear, and is equally suitable for winter or summer use. Extensive road tests have indicated that the new oil gave up to 12 per cent saving in fuel consumption on short runs and between 5 to 10 per cent on long runs.

Metallurgical Topics

Austenitic Chromium-Manganese-Nickel Steels Containing Nitrogen

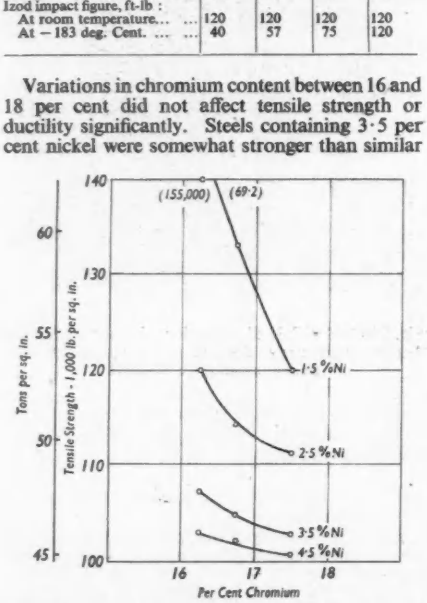
In view of their interest in developing high-manganese stainless steels to conserve nickel, Russell Franks, W. O. Binder and J. Thompson* have made a comprehensive study of chromium-manganese-nickel steels containing nitrogen with the object of ascertaining the composition giving stable austenite with the best mechanical properties and corrosion resistance. The investigation dealt with steels of relatively high nitrogen content to take advantage of the improved hot-workability imparted by nitrogen because of its stabilising influence on austenite.

It was found that steels containing chromium 16 to 17·5, nickel 3·5 to 4·5, manganese 7 to 9, carbon 0 to 0·10, and nitrogen 0·12 to 0·18 per cent had excellent austenitic stability. Large ingots of these steels should exhibit good hot-working properties if their initial hot-working temperature is kept at a maximum of 1225 deg. Cent. Steels within this category were found to have good mechanical properties in the hot-worked, solution-treated condition. A solution-treating temperature of about 1075 deg. Cent. was found suitable for imparting high ductility and toughness and, in this condition, the mechanical properties of the steels were comparable with those of the austenitic chromium-nickel steels. Some examples are given in Table I.

TABLE I.—*Mechanical Properties of 0·060in Thick Sheet Heated Fifteen Minutes at 1075 Deg. Cent. and Air Cooled*

Heat No.	900	888	895	883
Composition :				
Chromium, per cent	17	17	17	17
Nickel, per cent	3·5	3·5	4·5	4·5
Manganese, per cent	7	9	7	9
Carbon, per cent	0·10	0·11	0·063	0·066
Nitrogen, per cent	0·16	0·15	0·18	0·19
Properties :				
0·2 per cent yield strength, tons per square inch	20·5	21·7	20·8	21·2
Tensile strength, tons per square inch	49·2	48·6	46·1	46·8
Elongation, per cent	62	58	56	61
Izod impact figure, ft-lb :				
At room temperature... ...	120	120	120	120
At −183 deg. Cent.	40	57	75	120

Variations in chromium content between 16 and 18 per cent did not affect tensile strength or ductility significantly. Steels containing 3·5 per cent nickel were somewhat stronger than similar

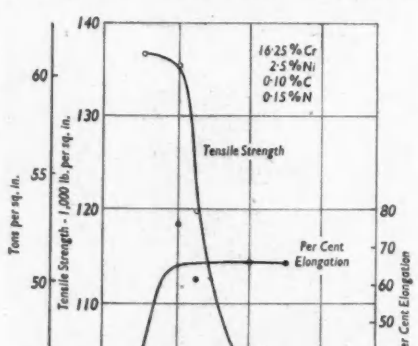


0·060in thick sheet, heated fifteen minutes at 1075 deg. Cent. and air cooled.

Fig. 1—Effect of chromium and nickel on the tensile strength of austenitic steels containing manganese 9, carbon 0·10 and nitrogen 0·15 per cent (Franks, Binder and Thompson)

steels containing 4·5 per cent nickel (Fig. 1); and steels with 7 per cent manganese were slightly stronger than those with 9 per cent (Fig. 2).

These variations, however, had no great effect on elongation. A high yield strength was characteristic of the high-nitrogen steels and this may be an advantage for structural purposes. Within the limits of composition stated above, however, differences in mechanical properties attributable to differences in carbon and nitrogen contents were found to be relatively insignificant. The work-hardening properties of these steels were intermediate between those of 17 : 7 and 18 : 9 chromium-nickel steels. They had good welding characteristics and welds made in them had high toughness both at room and sub-zero temperatures. The influence of manganese in



0·060in thick sheet, heated fifteen minutes at 1075 deg. Cent. and air cooled

Fig. 2—Effect of manganese on the tensile strength and elongation of steel containing chromium 16·25, nickel 2·5, carbon 0·10, and nitrogen 0·15 per cent (Franks, Binder and Thompson)

stabilising the austenite was helpful in retarding notch sensitivity at the low temperatures. The steels were not immune from intergranular attack after they had been heated for twenty minutes at 650 deg. Cent. or for two hours at 550 deg. Cent., but lowering the carbon to 0·06 per cent produced a marked improvement in resistance to intergranular corrosion. The relatively insignificant effect on susceptibility to intergranular corrosion of 0·15 to 0·18 per cent of nitrogen in the steels, as compared with that of carbon, was in agreement with previous experience which had shown that the precipitation of chromium nitrides was not so detrimental to corrosion resistance as the precipitation of chromium carbides. The general corrosion resistance of the steels in oxidising solutions and atmospheres was found to be comparable with that of 17 : 7 chromium-nickel steels.

* American Society for Metals, Annual Convention, 1954. Preprint No. 29.

Effect of Surface Tension on the Structure of Cast Iron

In spite of intensive research carried out in recent years, the process of graphite formation in cast iron is not yet fully understood. Much of the work described in recent publications on spheroidal and undercooled graphite structures deals with the question of whether graphite is formed from cementite which has first separated or directly from the melt. The mechanism of the formation of graphite structures is discussed but not the more general reason why spheroidal graphite should be formed instead of flake graphite. Some investigators, however, have sought to explain the differences in form of graphite by the influence of surface tension on the process of crystallisation, though without themselves having undertaken any measurements. In particular, B. Marincek, on general considerations, emphasised the importance of surface tension on graphite formation; and later, in conjunction with K. Grütter, published results of actual measurements from which it was inferred that the surface tension of ordinary pig iron and cast iron lies in the region of 800 to 1100 dynes per centimetre, whilst that of magnesium-treated cast iron with spheroidal graphite is 1300 to 1400 dynes per centimetre, which is approximately 40 to 50 per cent more than that of the original cupola-produced iron. This pronounced increase in surface tension of cast iron giving spheroidal graphite in comparison with ordinary cast iron giving flake graphite supported the assumption that surface tension can exert an influence on the form of graphite separating in cast iron.

Further experiments have now been undertaken by K. Grütter and B. Marincek* at Zürich. These were carried out on ordinary cast iron from the cupola and on the same iron after magnesium treatment or after inoculation with ferrosilicon. The surface tension was measured at temperatures of about 1330 deg. or 1400 deg. Cent. and the results considered in relation to the structural form of the graphite. Measurements were made by a capillary depression method nine minutes after melting began. Charges of 2 kg were melted as quickly as possible in an induction furnace under an atmosphere of argon. This took six to seven minutes, adjusting to the predetermined temperature one to two minutes, and preheating of the graphite capillaries about one minute. These consisted of a graphite block, drilled with two holes, 3mm and 6mm in diameter, and immersed vertically in the melt as shown diagrammatically in Fig. 1. The level of the liquid in each is depressed below that of the free melt by an amount depending on the diameter of the capillary. The iron melt produced a slight attack on the graphite, which gave a quite definite and exact indication of the level to which it had risen. On sectioning the block the difference in height (H) could be measured. To this must be added the difference in the heights of the meniscus (h). The necessary data and method of calculation of surface tension are given in a previous paper.†

Temperatures were autographically recorded by the aid of *Pt/PtRh* thermocouples. The surface tension at 1400 deg. Cent. of the flake graphite cupola iron was raised from 881 to 1395 dynes per centimetre by magnesium treatment, which resulted in a spheroidal structure. In the same way, experiments were made on cast iron treated with magnesium and inoculated to

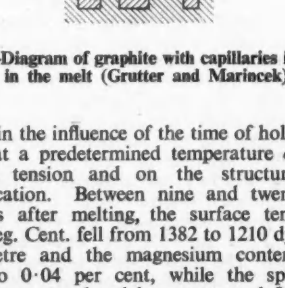


Fig. 1—Diagram of graphite with capillaries immersed in the melt (Grutter and Marincek)

ascertain the influence of the time of holding the melts at a predetermined temperature on their surface tension and on the structure after solidification. Between nine and twenty-eight minutes after melting, the surface tension at 1400 deg. Cent. fell from 1382 to 1210 dynes per centimetre and the magnesium content from 0·11 to 0·04 per cent, while the spheroidal graphite was replaced by rosette and finally by eutectic and flake formation. Similar experiments were made on hematite iron showing coarse graphite flakes and having a surface tension at 1330 deg. Cent of 950 dynes per centimetre. After magnesium treatment its surface tension was 1375 and its graphite spheroidal. Finally, the surface tension and structure of a synthetic

* *Archiv für das Eisenhüttenwesen*, September/October, 1954, page 447.

† *Giesserei, Tech. Wissensch. Beihefte*, October, 1953, page 587.

cast iron (carbon 3·5, silicon 2·0 per cent) were studied. In this, by additions of magnesium or of sulphur, in the form of iron sulphide, the surface tension could be varied over the wide range 1328 to 650 dynes per centimetre.

In these studies it was found that a given surface tension corresponded to a quite definite form of graphite. At a surface tension of 1300 to 1400 dynes per centimetre the graphite was spheroidal. Over the range 1100 to 1300 dynes per centimetre eutectic graphite and rosette formations were present. The ordinary cast irons, with surface tensions of 800 to 1100 dynes per centimetre showed flake graphite. The replacement of spheroidal graphite by the rosette type and finally by flake graphite, when heating of the magnesium-treated melt is prolonged, can be explained by resulphurising and oxidation, both of which tend to reduce the surface tension.

As a result of their investigations, Grütter and Marincek concluded that in given circumstances the surface tension of the iron melt can exert an important influence on the process of graphite formation, and thus on the form of the graphite.

Embrittlement of Tempered Martensite

THE fall in notched-bar impact value which results from tempering a fully hardened martensitic steel at 250 deg. to 350 deg. Cent. has long been recognised and various causes have been discussed to explain it. The tempering of martensite containing more than 0·25 per cent of carbon has been found to take place in stages. First, a network of the close packed hexagonal ε-iron carbide appears in the martensite sub-boundaries leaving martensite having an approximate carbon content of 0·25 per cent. This sub-boundary carbide either transforms directly to cementite or dissolves while cementite precipitates both in the martensite boundaries and within the martensite. With steels containing less than 0·25 per cent carbon, cementite is apparently formed direct from the martensite. It has been suggested that there is a correlation between the formation of cementite films at the martensitic boundaries and the embrittling phenomenon referred to above, often known as the " 500 deg. Fah. embrittlement."

In view of this difference in the process of formation of cementite in tempered steels of carbon content above and below 0·25 per cent, P. Payson* has carried out tests to ascertain whether steels of very low carbon content would show the embrittlement on tempering commonly shown by steels of higher carbon content when tempered at about 260 deg. Cent. Three steels of the following composition were employed :—

	A	*B*	*C*
Carbon, per cent	0·06	0·13	0·25
Manganese, per cent	0·46	0·50	0·53
Nickel, per cent	5·0	4·0	2·6
Chromium, per cent	0·46	0·48	0·47
Molybdenum, per cent	0·33	0·34	0·34

The nickel content was reduced as the carbon rose to avoid retained austenite. The steels were rolled from 30 lb ingots to ⅝in diameter bars which were air cooled from 870 deg. Cent. and tempered at 600 deg. Cent. Blanks for Charpy impact test pieces were prepared from these and were water-quenched after thirty minutes at 930 deg. Cent. and refrigerated in liquid nitrogen at −195 deg. Cent. After this treatment all the steels were fully martensitic. Specimens were tempered at 100 deg. Fah. intervals from 200 deg. to 1000 deg. Fah. (93 deg. to 538 deg. Cent.), and were tested at room temperature. Additional tests were made at −73 deg. and +150 deg. Cent. The results, shown in Fig. 1, suggested that the low carbon content of the martensite, obviating the initial formation of ε-iron carbide, did not change the fundamental conditions responsible for the embrittling produced by tempering in the range 250 deg. to 350 deg. Cent. and that, by varying the testing temperature, the embrittlement becomes evident independently of the quantity of freshly formed cementite. On the other hand, the composition definitely affected the transition temperature of the tempered steel. Thus, the transition temperature of steel *A* (carbon 0·06, nickel 5 per cent), fully hardened and tempered at 350 deg. Cent., was below room temperature, whilst

* *Journal of Metals*, November, 1954, page 1242

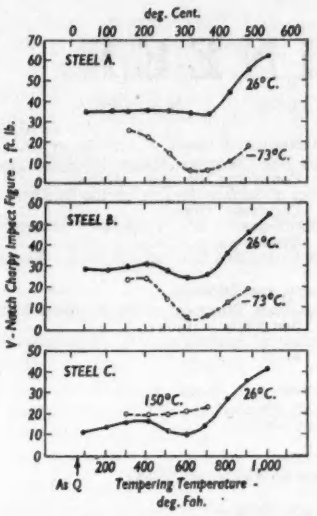


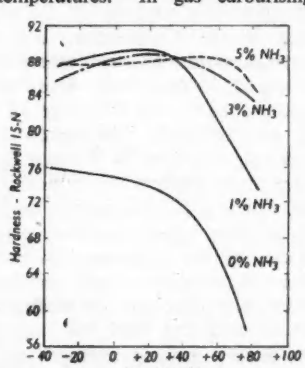
Fig. 1—Effect of the composition of the stee land of the testing temperature on the minimum in the impact figure/tempering temperature curve (Payson)

that of steel *C* (carbon 0·25, nickel 2·6 per cent) was above room temperature. In general, the lower the carbon content and also the higher the nickel content, the lower is the transition temperature of a steel so treated. As shown in Fig. 1, the negligible dip in the room-temperature impact figure/tempering temperature curve of steel *A* becomes quite definite if the tests are made at −73 deg. Cent., whilst the more pronounced dip in the room-temperature curve of steel *C* is eliminated by testing at +150 deg. Cent.

Gas Carburising and Carbonitriding

ONE of the advantages claimed for the carbonitriding process of case hardening of steel is the satisfactory performance of furnace atmospheres containing larger concentrations of water vapour than can be tolerated in gas carburising. Most of the early work on carbonitriding was carried out with a high concentration of ammonia (30 or 40 per cent) in the inlet gas, but ammonia additions have been reduced to 10 per cent or less in current practice.

Water vapour tends to decarburise steel at high temperatures. In gas carburising, the



Mild steel specimens case hardened four hours at 845 deg. Cent. and oil quenched

Fig. 1—Surface hardness as a function of water vapour concentration (dew point) for different concentrations of ammonia in a case hardening atmosphere containing also 5 per cent methane, balance carrier gas

presence of water vapour in a strictly limited range of low concentrations is said to have a beneficial effect in activating the surface of the steel, but in larger amounts it tends to prevent carburisation. On the other hand, in a recent survey of industrial carbonitriding practice it was pointed out that high dew points are found in the gas employed in some commercial installations in which carbonitriding is carried out successfully.

To investigate the difference in the behaviour of water vapour in the two processes, P. A. Clarkin and M. B. Bever* have studied the role of water vapour and ammonia in case hardening atmospheres consisting of carrier gas, together with 5 per cent of methane and various amounts of ammonia up to 5 per cent in the gas. Specimens of mild steel were case hardened in a muffle furnace for four hours at 800 deg., 845 deg. and 885 deg. Cent. and quenched in oil. These temperatures were lower than the normal gas carburising temperature and this may account

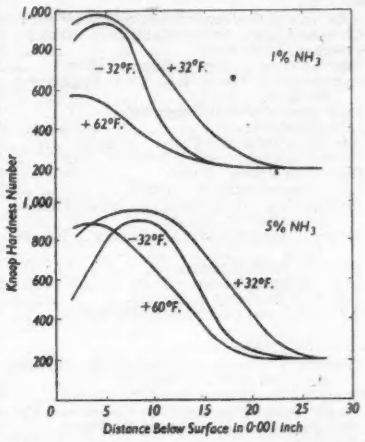


Fig. 2—Microhardness across the case of specimens treated as in Fig. 1. Temperatures indicate dew points

for the relatively low surface hardness attained in the absence of ammonia. As the results were similar at all three temperatures, only those obtained at 845 deg. Cent. will be referred to. In Fig. 1 the surface hardness is shown as a function of water vapour concentration (as measured by the dew point) for different concentrations of ammonia in the case hardening atmosphere. There is a decrease in hardness at high concentrations of water vapour ; but with increase in ammonia content the decrease in hardness sets in at a higher dew point. There is also some evidence that, in the presence of ammonia, the surface hardness decreases slightly in the region of low dew points. Microhardness values were lower in specimens case hardened in atmospheres with high dew points, especially if the concentration of ammonia was low. Fig. 2 shows a few typical curves selected from the complete set of diagrams in Clarkin and Bever's paper. An intermediate dew point, for example, 32 deg. Fah., yielded the best microhardness profiles. The curves show a maximum at a small distance below the surface. In the ascending branch of the curves, produced by carburising in atmospheres having low dew points, the hardness increased because of decreasing amounts of retained austenite : the descending branch of the hardness curves was caused by the fall in carbon and nitrogen contents with increasing depth of the case. The maximum tends to disappear with increasing dew points. Case depths were greatest for intermediate dew points. Chemical analysis showed a pronounced decrease in carbon content of the case as the dew point increased ; but with constant amounts of ammonia in the gas the nitrogen content of the case was not appreciably affected by its dew point. The decrease in carbon absorption with increasing water vapour concentration was paralleled by a decrease in retained austenite. Decreasing concentrations of ammonia in the range 5 per cent to zero were accompanied by a slight reduction in the nitrogen content of the case, and also by some decrease in the carbon content, especially at higher dew points.

This suggests that there may be beneficial effects to be obtained by adding to a gas carburising medium small amounts of ammonia in concentrations below the level required for carbonitriding. The different effect of water vapour in gas carburising and in carbonitriding is evidently due to the presence of ammonia in sufficient amount to counteract its influence in the carbonitriding process ; but the true nature of the phenomenon would appear to need further study.

* American Society for Metals, Annual Convention 1954 Preprint No 31

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THE COAL AND STEEL AGREEMENT

The signing in London last week of the agreement between the United Kingdom Government and the European Coal and Steel Community brought to a satisfactory conclusion discussions which have been in progress over the last twelve months. When the Community came into being just over two years ago, the British Government declared its desire to establish "an intimate and enduring association" with it, even though it felt that it could not be bound by the principles of membership. That association has undoubtedly been advanced by the new agreement which establishes a "Standing Council of Association" composed of four representatives of the British Government and four representatives of the Community's High Authority. The British representation will include a member of the Government "whenever possible," and one member each of the National Coal Board and the Iron and Steel Board, in view of the powers and responsibilities which legally rest upon those bodies. This Council is to be the vehicle for continuous consultation about "matters of mutual interest relating to coal and steel," and for consultation as to the co-ordination of action "to deal with these matters consistent with the international obligations of the parties concerned." In outlining the terms of the agreement in Parliament, the Minister of State for Foreign Affairs, Mr. Nutting, said that the Council would examine "restrictions and other factors affecting normal trade in coal and steel between the two areas, with a view to making such proposals for their reduction or elimination as may be agreed for the mutual benefit of the United Kingdom and the Community." Yet another provision in the agreement is for special meetings between the British Government and the Council of Ministers of the Community, in which the High Authority would participate.

From its inception, the High Authority of the European Coal and Steel Community has been concerned with finding ways for achieving an increasingly better understanding with the countries outside the Community. Up till now, co-operation between the High Authority and this country has been effected by a United Kingdom delegation which has regularly exchanged views with the Authority on matters of common interest. The agreement now made will strengthen that co-operation, good as it already is, by putting it on to a rather more official and permanent basis. It is an agreement into which neither party has entered without careful consideration of the complexity of some of the problems associated with Europe's coal and steel industries. Coal and steel continue to be about the most important factors in the economy of Europe, and they are certainly factors of particular importance to the economy of the United Kingdom. Admittedly at present there is little trade in either between this country and the member countries of the Community, but, when world requirements of steel especially are considered, it is manifestly desirable that there should be a free exchange of commercial and technical information among the producing countries of Western Europe. There are many matters of common interest for the Council of Association to study. They have been broadly defined in one of the articles of the agreement as including conditions of trade in coal and steel between the United Kingdom and the Community; supplies of coal and steel and supplies of raw materials; pricing arrangements and factors affecting the price structure; trends of production and consumption; effects of the development of other sources of energy and substitute materials on coal and steel requirements; technical developments and research, and arrangements for the promotion of safety, health and welfare of persons employed in the two industries. The Council will also be competent to examine, if required, such matters as quantitative restrictions on imports and exports, tariffs and other charges, exchange control restrictions, dumping and anti-dumping measures, and export subsidies. The signatories to the agreement clearly intend, therefore, that the Council shall constitute a forum for the discussion of all the major problems likely to be encountered in the coal and steel industries of Western Europe. Moreover, in carrying out its functions, the Council is required, by the terms of the agreement, to have regard to the interests of consumers as well as producers, and to keep in mind "the special relationship between the United Kingdom and other members of the Commonwealth of Nations."

It should not be overlooked, however, that this closer liaison envisaged by the establishment of the Council of Association in no way limits the freedom of the United Kingdom in determining the policy of its own coal and steel industries. It will be recalled that when the European Coal and Steel Community was created the British Government was invited to take part in the negotiations. But membership of the Community involved the prior acceptance of two principles, namely, the pooling of coal and steel resources and the establishment of a High Authority "whose decisions would bind the Governments concerned." Agreement with those two principles, which have come to be generally known as fusion and "supra-nationalisation," might well have had repercussions upon this country's trading arrangements with the Commonwealth and other countries. The Government therefore quite understandably came to the conclusion that membership of the European Coal and Steel Community would not be in the best interests of this country's economy and commerce. The present agreement in no way implies any departure from that decision. Nevertheless, it does open the way to a fuller and freer exchange of information on matters of mutual concern to all the countries which are parties to it. That, as was emphasised after the signing ceremony, can undoubtedly make a useful contribution to the unity and prosperity of Western Europe.

NUCLEAR PLANTS FOR SURFACE WARSHIPS

Though the possibility of using a nuclear power plant in aircraft is still under investigation in the United States, and possibly also in this country, the weight and size of the shielding required appears to counteract the advantages except perhaps for very long-range craft. The aircraft, it seems, would need to be at least as large as the conventional long range bomber—such as the "B-36" or "B-52." But those craft already have sufficient range to deliver a bomb load on any likely target. In a warship, however, the weight and size of shielding present lesser difficulties, while the almost negligible consumption of uranium fuel, even if the vessel is proceeding at the fastest speed for which the engine is designed, would have immense operational advantages. Comparing the heating value of uranium and oil on a volume basis, one cubic inch of fissioned uranium is equivalent in heating value to no less than 30,000 cubic feet of fuel oil! That comparison is, of course, misleading; allowances should be made for thermal efficiencies and other factors. But it does reveal how great an amount of space could be assigned without disadvantage to shielding. It is true that the development of the fleet train since the first world war has done much to reduce the need for refuelling ports, but the maintenance of

fleets and squadrons at sea for long periods is still a major problem. Owing to the probability of submarine or aircraft attack, Task Forces and squadrons will require to steam at high speed, with a heavy expenditure of fuel, necessitating a constant stream of vulnerable tankers moving to and from the fleet train and the nearest oil fuel base, the latter itself perhaps open to bombardment by nuclear weapons.

So far it has only been possible to try out a nuclear plant in submarines. The United States has one such submarine nearly completed, another under construction and a third is to be started during the current fiscal year. But a nuclear plant is now being manufactured for an aircraft carrier or other large vessel and it cannot be long before it is installed in a surface ship for trial. In a submarine the question of range is not of vital importance. At the relatively slow speeds practicable when using their snorts, existing submarines have a radius of action of thousands of miles and their operations are unlikely to be curtailed by shortage of fuel. The main advantage of this kind of plant for an underwater vessel lies in the fact that it requires no air for combustion. The vessel is changed from a submersible—a vessel which submerges only when necessary—to a true submarine, normally operating and navigating fully submerged. She is thus able to use her engines under water without the aid of a snort ; and if they are turbine engines her submerged speed may be as much as 25 to 30 knots. But the weight and size of the shielding at present necessitates an unduly large submarine — the U.S. " Nautilus " is well over 3000 tons—which is likely to make her unhandy and an easy target for asdics. It may well be, indeed, that the small British submarine " Explorer " —launched nearly a year ago—is no less a true submarine than the American vessel. She has propulsive machinery using hydrogen peroxide and is able to maintain a speed of well over 20 knots when fully submerged.

For surface vessels on the other hand—particularly for cruisers and destroyers of a Task Force—the advantages of being able to cruise for indefinitely long periods at very high speed can hardly be over-emphasised in any future war. Enemy forces—whether cruisers and submarines or aircraft—would have the greatest difficulty in locating a Task Force able to steam indefinitely at 30 to 35 knots without refuelling. And this difficulty would be much enhanced when faced with early warning aircraft patrols. High speeds of this nature would facilitate the landing-on of modern aircraft on medium-sized carriers and greatly increase the difficulties of submarine attack. For high speed is not only a safeguard in itself in reducing the area in which an attack is possible but high-speed submarines of the " Nautilus " type would hesitate to make a close range attack in view of the increased " hydrophone effect " heard from a fast-moving ship in the asdic installation. Nor could attacks be made at long range with acoustic or other homing torpedoes unless their present speeds could be very much increased. There would also be the great advantages of using some of the space now reserved for oil fuel tanks for other operational requirements and the saving of material and resources expended in building and defending naval tankers and in storing oil fuel underground at bases subject to air attack. As soon, indeed, as there is good evidence that a nuclear reactor is as reliable and efficient as the conventional plant there seems every reason, apart from cost, to use it to power all our new surface ships which are likely to be required for Task Force operations. To judge from the " Nautilus," which even with a small reactor is to cost nearly £18,000,000, the cost of installing an atomic power plant at the present time may seem almost prohibitive for this country. It must, however, be remembered that the technology of power producing reactors is new and there is every hope that developments will soon close the gap between the cost of the conventional and the nuclear plant. Furthermore, the saving in fuel cost must be set off against the first cost of the plant. It is by no means impossible that the economics of nuclear power might prove more favourable at sea, particularly for a warship, than on land.

Obituary

THOMAS WIGHTMAN CHALMERS

We regret to have to record the death on Wednesday of last week of Dr. Thomas Wightman Chalmers, who joined the editorial staff of this journal in July, 1909, and spent the rest of his working life in its service.

Dr. Chalmers came of an engineering family, for his father was with Neilson and Co., Hyde Park Locomotive Works, Glasgow. Dr. Chalmers was born in 1884 and after an education at Glasgow High School he served an apprenticeship with Nelson Reid and Co., later the North British Locomotive Company. He also attended Glasgow University, conceiving there an admiration, due to last his whole life, for Professor Barr. He graduated in 1908, and in the following year joined the staff of this journal. For many years before and during the second world war he served as chief technical assistant editor and after the retirement of the late L. St. L. Pendred from the editorial chair he became consultant editor to the latter's successor. In 1932 he graduated as a Doctor of Science at Glasgow University.

Curiously, considering how in its beginnings his life had been associated with that very practical engineering art, the building of locomotives, the trend of his mind lay much more towards the scientific side of engineering. Indeed, the purer sciences held a particular interest for him and towards the end of his life he contributed a notable series of articles entitled " Historic Researches " to the pages of THE ENGINEER and followed them up with further series of articles upon more modern scientific subjects. After retirement he continued to be engaged upon the extension of the series. But it would be totally wrong to suppose that practical matters escaped his attention. In another, earlier, series of articles on " Historic Accidents and Disasters " he revealed both the analytical turn of his mind and a strong appreciation of practical requirements in engineering structures. As a writer he was capable of being astonishingly lucid about complicated subjects and though he was a mathematician of very high ability he appreciated that others were not and, therefore, much preferred to convey ideas in words rather than in the form of equations wherever it was possible to do so.

But within this office it will not be for the loss of a skilled editor and writer that we shall mourn his passing. It is as a man with his own human foibles, including a meticulous attention to detail, his own rather dry humour (he loved to be chaffed about his Scots' ancestry), and his own underlying kindliness, not always immediately apparent to those first meeting him that we, and the very many friends and acquaintances that he made, will best remember him.

Literature

An Introduction to Cost Accountancy. Vol. I. By R. WARWICK DOBSON. London : Gee and Co. (Publishers), Ltd., 27–28, Basinghall Street, E.C.2. Price 35s.

THE value of a good system of cost accountancy is being increasingly recognised by engineers, who in days gone by regarded it with a degree of disfavour, largely because from the outset there had been a lack of co-operation between the cost accountant and the management. Nowadays, however, the works manager realises what a useful aid to his own work a reliable costing system can be, and he will welcome the very thorough manner in which Mr. Dobson deals with his subject, probably in a more comprehensive manner than has been attempted in any former treatise on the same theme. No longer is the main purpose of cost accountancy deemed to be of assistance in fixing selling prices, but rather is stressed its use in controlling costs. If such costs are to be of use it is essential that their presentation as the final cost of an article should be available as soon after its completion as possible, for as rightly stated " modern managers demand news, not history." We should like to have been given an indication as to the author's views as to what he considers a reasonable lapse of time between the two.

After an introduction which clearly defines the scope of cost accountancy and its various divisions, the subject is broken down in fifteen chapters, the first of which is general to costing, setting out the costs that are to be ascertained, and showing how primary costs are linked with the different cost centres and cost units, each of which has a chapter devoted to its consideration (Chapters V and VI), the intervening chapters dealing with the important subject of primary cost, involving material costs, wages and " expense " respectively (Chapters II to IV). The actual process of costing is then described, including procedure, the different cost rates and their apportionment, and methods of dealing with overhead expenditure (Chapter VII). The way in which costs are classified next comes under review, first by characteristic, and secondly by nature and function (Chapters VIII and IX). Now follows a very useful description of the different methods of costing, embracing standard costing (Chapter X), marginal costing, which is designed to overcome some of the difficulties incident to historical and standard costing (Chapter XII), and uniform costing for which the author feels there is a very definite need (Chapter XIII), while Chapter XI is devoted to variance allowance, showing the necessity for a very careful investigation of the variations between the standard cost and that actually incurred. The important subject of so-called budgetary control is very thoroughly developed (Chapter XIV), and though in itself it does not control, it is highly valuable for control purposes. The author states that " budgetary control operates as a complement to standard costing." The concluding chapter (XV) deals at considerable length with cost control, it rightly being pointed out that there is a

real danger of building up a very complex system without properly considering how best the costs so determined can be used to assist management. We cannot help feeling that this chapter is a counsel of perfection. Before each chapter will be found a brief summary of its contents. We should have welcomed a bibliography indicating suitable books dealing with analogous subjects which Mr. Dobson has wisely left to others. The foregoing will give the reader a general idea of the ground covered. It will probably have been noticed that no reference has been made to the various mechanical and other aids available to the cost accountant, nor to methods employed, and the general organisation, but all this is left over to Volume II, while a third volume is devoted to the subject of cost recording and presentation.

While the whole subject is handled in a thorough and consistent manner, the author evidencing a very open mind, there are a few points that seem to call for comment and perhaps require further elucidation. We always welcome a "family tree" in books of this nature, and instead of the usually recognised one we are favoured with a novel alternative in a shape of a series of circles, the inner of which represents the board of directors, and the outer the various clerks, operators, &c. We are surprised to find in it no place for rate fixing, estimating and other kindred functions. Again, in an interesting illustration of a factory layout to show the different cost centres, we cannot but suggest that it is not a good arrangement to have the general office, with accounts, costing, &c., at one end, while at the other, as far away as possible, is the works manager's office and staff, the personnel department and production generally. Surely this will not tend to produce the co-operation so essential to success. While the various rates for absorption of overheads are carefully described, we should have been glad to know if the author had any preference. He says that the chief drawback to the machine-hour rate is the additional clerical staff involved, but it is felt that if the best results are obtained this way, the increase in clerks is justified. When this method is in use it is important for the estimating department to be careful in "slump" periods, and to realise that a large potential order will reduce the rate materially, but, as the author observes, "something of the ability of a seer is really required to compile a reliable estimate." We should have liked to see very much closer collaboration advocated between the estimating department and that of costing. Whether, as suggested, estimating should be placed under the sales organisation or rather be more closely linked with design and development is open to question, but while we may prefer the latter, it is admitted that each has its own advantages, and probably the governing factor will prove to be the nature of the factory concerned. We should like to know what Mr. Dobson's views are as to the substitution of thirteen four-weekly periods in the year for the usual twelve calendar months. The engineer would say that the equal accounting periods give a more reliable picture for period by period comparison of costs. Perhaps the author has gone rather far in his wholehearted advocacy of uniform costing; we have in mind that it sometimes occurs that the same engineering works produce in bulk where standard costing is ideal, but at the same time cater for other products which are more satisfactorily dealt with by another system.

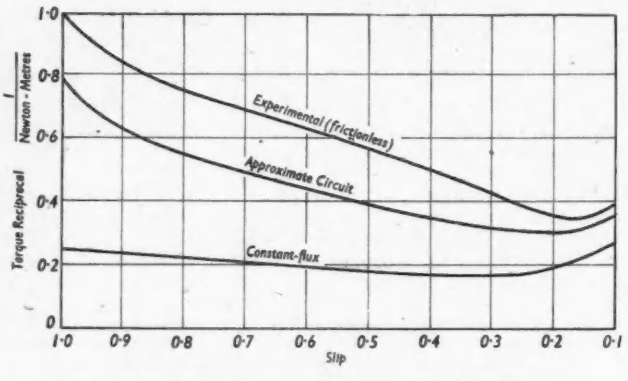
The foregoing remarks are not intended in any way to discount the value of a useful work which can be commended to the industrialist who wants to organise on up-to-date and logical lines.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

ELEMENTARY TREATMENT OF THE POLYPHASE INDUCTION MOTOR

SIR,—Messrs. Parton, Ph.D., M.I.E.E., and Gashus, B.Sc., have performed a useful service in pointing out the large errors arising from the use of the over-simplified constant-flux assumption in the calculation of the torque maxima and starting time of induction motors. Their reiteration of the desirability of instructing students in a method of calculation which is consistent with the circle diagram should find wide approval.



Reciprocal torque-speed curves of polyphase induction motor

The student and, indeed, the practising engineer, usually finds comprehension easier when he has two mutually consistent ways of viewing the same problem. One might, however, wish that the latter part of the article had considered more fully the effects of windage and friction losses. Their quite appreciable effect on starting time should be pointed out to students at the same opportunity.

It will be noted that the torque-slip curves on page 657 are all for gross torque, and that the experimental values have been modified appropriately. In this way it gives a clear picture of the differences due to method of calculation. In Table I, on the other hand, there appears to be lack of consistency. The time of 1·7 seconds for acceleration from rest to 900 r.p.m. obtained from the constant-flux expression clearly assumes no friction, whereas the experimental time does not appear to have been corrected for no friction as in the case of the torque curves. The expression for starting time based on the approximate circuit will yield a result of 3·7 seconds, again assuming no friction.

A graphical check is made by plotting the reciprocal function of the torque as given in Fig. 2 (page 657) on a similar base representing (1—slip). Then to some scale determined by J, the ordinates represent reciprocals of angular acceleration. Graphical integration over the desired range of angular velocity quickly determines the time interval.

The comparison of the three made on a strictly consistent basis is quite sufficiently revealing of the large discrepancies occasioned by the constant-flux assumption.

In order to introduce the effect of windage and friction into the above consideration of starting time, the graphical derivation can be modified by taking net torque output (subtracting from the calculated values of torque the torque losses as determined by practical tests). In common with many graphical methods, it has the merit of presenting a lucid mental picture.

The following results have been obtained by such use of Fig. 2 and a reciprocal set of curves has been plotted therefrom :—

	Rest to 900 r.p.m. $s=1$ to $s=0·1$
	Sec
Constant flux	1·7
Approx. circuit	3·6
Experiment	4·8

Kindly note an apparent misprint in Table I. For the Approximate Circuit, $T'_{max}=3·23Nm$ (not $5·96Nm$) in conformity with the value given in the penultimate paragraph of page 657.

BERNARD BRAMALL, B.Sc., A.M.I.C.E.
Ontario, Canada.
November 29, 1954.

EXPLOSION CHARACTERISTICS OF A LUBRICATING OIL MIST

SIR,—In our paper entitled "Explosion Characteristics of a Lubricating Oil Mist," which appeared in your issue of July 30th, we stated with regard to Shell Talpa Oil 30 that "in a straight distillation this came over in the range 153 deg. Cent. (first drop) to 398 deg. Cent."

It has been suggested to us that this statement may give a misleading impression regarding the volatility of the oil and we therefore wish to emphasise that the bulk of the oil distilled at well over 300 deg. Cent. The temperatures measured were those of the vapour coming over during distillation but the temperature of the surface heating the liquid oil was probably considerably higher. Moreover, the distillation was carried out at atmospheric pressure, a condition that is relevant to the formation of mist from oil in contact with an over-heated engine part but that is liable to give rise to thermal-cracking. Had information regarding the volatility of the uncracked oil been required, distillation would have been carried out under vacuum.

J. H. BURGOYNE
D. M. NEWITT
A. THOMAS

London, S.W.7.
December 16, 1954.

Short Notice

Grundzüge der Zerspanungslehre. By Max Kronenberg. Second edition. Berlin: Springer-Verlag, Reichpietschufer 20, W35. Vol. I: Single-Point Cutting. Price DM48. (In German).—Dr.-Ing. Max Kronenberg is an international authority who can look back on over thirty years' research and practice in his field of tool engineering, first in Germany and later in the U.S.A. In preparing the present edition of his book on "The Fundamentals of Metal Cutting Science," which first appeared in 1927, he has succeeded in synthesising a wealth of data obtained during the intervening years, into a systematic review which should be of interest both to the scientist and to the practical engineer. During the last quarter of a century higher tool capacities and a six-to-sevenfold increase in driving power have resulted in a similar increase in the rate of metal removal. This is a remarkable extension of the range of data for which theory must account. Nevertheless, it was found possible to fit the new knowledge into the already established scientific framework and to express the results, as before, in terms of the cutting speed and the cutting force factors. The book is divided into two parts, the first dealing with basic theory and the second with the technological aspects. After considering the mechanics of the cutting action and its effect upon the physical properties of the workpiece, the author shows how dimensional analysis can be applied to derive a "general" form of Taylor's equation for the endurance of a tool. This part concludes

with chapters on the effect of temperature and of lubrication, and on the geometry of the cutting edge. In the technological section the effects of cutting speed and cutting pressure are discussed in detail in relation to rate of metal removal, power required, and tool endurance, and research results from many different sources are correlated. This part is rounded off by a discussion of a number of practical cases. There are two appendices in which are collected the most important formulæ, together with the "best" values of the coefficients involved, data on physical constants and other useful tables.

Reibscheiben-Regelgetriebe. By Dr.-Ing. W. Thomas. Braunschweig: Friedr. Vieweg and Sohn. Price DM 19,80. (Obtainable from Lange, Maxwell and Springer, 242, Marylebone Road, London, N.W.1.)—This volume on variable-speed friction drives is the fourth of a series dealing with drives and transmissions which is being issued by the Verein Deutscher Maschinenbau-Anstalten e.V. (VDMA). The treatise is based on theoretical work of Weber and Niemann, further developed by Kutter, and discusses the friction and force relations in a number of representative drives. An extensive appendix contains tables of mathematical functions used in the calculations, many diagrams of layouts, and a description of experimental work carried out at Braunschweig Technical University.

Textbook of Illuminating Engineering. Second edition. By J. W. T. Walsh, M.A., D.Sc. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 28s.—The aim of this book is to assist students who are preparing for the examination in Illuminating Engineering (Intermediate Grade) of the City and Guilds of London Institute. The new edition has been brought into line with the current syllabus of the Institute, and the nomenclature has been changed in accordance with the recommendations of the International Commission on Illumination (C.I.E.) in 1948 and 1951. Certain sections, especially those describing discharge lamps, have also been brought up to date. After a discussion in Chapters I to III of the basis of the subject in physics and physiology, there follows a description of the principles of light measurement. The various kinds of light (daylight, gas, and electric light) are discussed next, followed by chapters on the principles and practice of lighting design. The book concludes with a set of examination questions, which are mainly of a descriptive nature.

Books Received

Power To-day and To-morrow. By F. Sherwood Taylor. London: Frederick Muller, Ltd., Ludgate House, 110, Fleet Street, E.C.4. Price 15s.

The Load on Top Management: Can It Be Reduced? By L. Urwick. London: Urwick, Orr and Partners, Ltd., Urwick House, 29, Hertford Street, W.1. Price 2s.

Engineering Drawing Problems. By Frank Zozzora. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 30s.

Metallurgy of the Non-Ferrous Metals. By W. H. Dennis. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 70s.

Water Conditioning for Industry. By S. T. Powell. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 64s.

Metallurgical Abstracts, General and Non-Ferrous, Vol. 20, 1952–53. Editor, N. B. Vaughan. London: The Institute of Metals, 4, Grosvenor Gardens, S.W.1. Price 60s.

Electricity Undertakings of the World, 1954–55. Sixty-fourth edition. Edited by N. H. Codling. London: Benn Brothers, Ltd., 154, Fleet Street, E.C.4. Price 30s.

"Cassel" Manual of Heat-Treatment and Case-hardening. Sixth edition. Published by the Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1. Price 15s.

Analog Methods in Computation and Simulation. By W. W. Soroka. London: McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 53s. 6d.

Experimental Science and Civil Engineering Research*

By FREDERICK MEASHAM LEA, D.Sc.†

On Tuesday, December 14th, Dr. Lea delivered the fifth Unwin Memorial Lecture at the Institution of Civil Engineers. Abstracts from this lecture are printed here. Dr. Lea considered some of the developments in experimental science that have contributed to modern advances in civil engineering research, and gave numerous examples of the development of new techniques of measurement in structural engineering investigations, some of which form the basis of these abstracts.

THE need for new or improved methods of measurement has stimulated the application of well-known principles of classical physics in the form of reliable instruments suitable for engineering measurements in the laboratory and the field. Both new principles and applications of old ones have now rendered possible quantitative measurements of phenomena that were previously inaccessible or at best only crudely measurable.

The direct measurement of displacement by gauges of one sort or another, and by extensometers in which the movement is multiplied by optical and mechanical levers, is too familiar to need any comment. I propose, therefore, to mention only the application of some other old physical principles and the utilisation of some newer ones.

In principle any physical property of a material that is changed by deformation can form the basis of measurement of strain. The changes in electric resistance, or in the natural frequency of vibration of a wire, with changes in tension, have long been known, but their development into useful and reliable methods of measurement has come only relatively recently. The need for them was the spur that led to their development. Electrical capacitance and magnetic induction are other well-known physical phenomena that have been similarly utilised, and also, to some degree, magneto-striction, the change in volume of a magnetic material when it is placed in a magnetic field. The piezo-electric effect, by which certain substances when subjected to pressure, develop an electric potential between different crystal faces, forms the basis of an invaluable method for measuring high-frequency vibrations. An early example of its application in civil engineering research may be found in the measurements made by Glanville and Grime of the passage of pressure waves in a concrete pile during driving.

The reverse effect we see in the electro-mechanical transducer in which the change of dimensions of crystals, such as those of Rochelle salt and barium titanate, on application of an electric field, is used to generate pressure waves in a solid. The development of electronics has now provided means of producing high-frequency voltage pulses of adequate power and of methods of measuring them. This combination of modern electronics and the classical physical principle of piezo-electricity has thus given us the ultrasonic method of testing in which the velocity of propagation of a pulse of high-frequency waves through a solid is measured. As applied to concrete it can be used on a laboratory specimen, or on mass concrete *in situ* up to 40ft in thickness. Though much remains to be done, we have here a weapon that enables the engineer to probe into the interior of a concrete mass.

It will not have escaped your notice that with all the means now at our disposal we are still limited in general to the measurement of strain and only indirectly of stress. Though the engineer would much like to be able to measure stress directly, this is rarely possible in solids and even the so-called stress gauges depend on a deformation to bring their mechanism into play, resulting almost inevitably in some inequality in stress between the measuring instrument and the solid on which the measurements are made. The major exceptions are fluid gauges in which the pressures inside and outside the gauge can be balanced. Such gauges can be used very successfully, for the measurement of the pore-water pressure in soils, but they are ill-adapted for use within solid bodies. If future developments should give us a direct and reliable method of measuring stress in solids, yet another important weapon will have been added to the engineer's armoury.

The importance of new methods of measurement is well-illustrated by present trends in civil engineering research. The engineer needs first to know the properties of materials. The study of these, and of the individual components of structures, has long been the concern of research and testing laboratories. These give the essential data that the engineer applies in the design of structures, checking by conventional assumptions that the stresses or deflections in each member do not exceed certain permissible values for the assumed working loads. There is now developing, as you know well, a new approach to design, based on the properties of a structure as a whole and not merely on the analysis of its individual parts. Its future development requires much more information, not only on the properties of structures as a whole, but also of the more subtle properties of materials. Whilst the newer methods of measurement have been very valuable in laboratory investigations, they have often been essential to studies of actual structures. The ability to measure transient effects produced by impact or dynamic loads and the relative ease with which appropriate gauges, recording at a distance, can be fixed to structures to give permanent records of changes over long periods of time, now permit of observations of a type that were often previously impracticable. The importance of the study of actual structures and of the relation between design calculations and actual stress distribution is illustrated by the action of this Institution in arranging for a conference to be held next autumn on "The Correlation Between Calculated and Observed Stresses and Displacements in Actual Structures."

I have so far passed rapidly over some of the general ways in which physical principles—old and new—have been adapted to provide reliable measuring instruments. In the remainder of this lecture I should like to

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† Director of Building Research, D.S.I.R.

give some illustrations of their use in engineering research.

An Investigation of a Steel-Framed Building

An investigation on the stiffening of frames by floors and walls, affords an example where modified forms of measuring instrument needed to be developed. In order to obtain data on the structural interaction between the various parts of a building, measurements were made of the stresses in some of the beams and stanchions in the steel frame of a large office building in London. It was thought desirable to determine the complete stress history for these members, during construction, during special loading tests, and over a period of years for normal conditions of use. The strain gauges to be used had to be stable over long periods, resistant to the impact and vibration associated with construction of the building, and suitable for burying within the concrete encasement of the steelwork. Since large numbers of gauges were to be used and it would be impracticable to recover most of them, the design had to be simple and cheap.

None of the gauges previously used immediately satisfied these requirements. From the point of view of stability and reliability, only the vibrating wire gauges appeared to be suitable ; but the form in which it had been developed for bridge tests was too expensive and not sufficiently robust for a long-term investigation on stresses in buildings. Accordingly, a new form of vibrating wire gauge was specially designed. In order to avoid the risk of slipping of the knife-edge mounting, the wire was stretched between two steel posts screwed into prepared holes in the structural member. With this type of fixing, the gauge length is not so precisely defined as is possible with knife edges, but the error in strain estimation is of negligible importance. The posts are fixed at 6in centres, firmly held in position by lock nuts. The wire, of 0·018in diameter, passes through a hole in each post and is fixed by means of a tapered pin driven into a second hole at right angles to that for the wire. The arrangement of holes, wire and pin is such that the driving home of the pin firmly grips the wire, squeezing it by about one-third of its diameter. In mounting the gauge one end of the wire is first fixed ; the wire is then stretched by a calibrated spring to a predetermined stress before the second end is fixed. The free vibrating length of wire is accurately measured for each gauge.

All the components were made from a special stainless steel. The wire had to be magnetic, rustless, and free from creep at its working tension. In operation the wire is plucked by discharging a condenser through a small electromagnet held close to it ; the same electromagnet picks up the vibration and the oscillating electric potential is amplified and fed to earphones or a cathode-ray tube. Comparison of the vibrations with those of a reference gauge is made aurally by the elimination of beats, or visually by a study of the Lissajous figures produced by the test gauge and the reference gauge on the screen of the cathode-ray tube.

For gauges buried in concrete, the electromagnet is mounted in a heavy cast iron cover, which protects the gauge during construction of the building and keeps out dirt and damp. The cover is made watertight by sealing the base with a bituminous compound. The leads from the electromagnet are taken to a convenient measuring station. Since the measurements are concerned solely with frequencies of oscillations there is no need to take special precautions with electrical connections and the switchgear used for a large group of gauges can be very simple. In this respect, the vibrating wire gauge has an important advantage over the electrical resistance gauge.

Sixty gauges were fitted initially to beams and stanchions in the basement for studying the effect of settlement of the building. Later, a further ninety-two gauges were fitted to beams at third-floor level for studying the composite action between the beams and their encasement and the floor slabs. The results will be described fully elsewhere, and it suffices to mention here that the tests have shown the great importance of composite action and the need for further work, both in the laboratory and on actual structures, to obtain data so that proper allowance can be made for these effects in design.

Loads in a Tunnel Lining

Another development in the use of the vibrating wire gauge is afforded by the measurements made of the loads and of the changes in diameters in tunnel linings. Here a gauge was required which would function satisfactorily over long periods and under water.

In a new type of lining for a water pressure tunnel being developed by the Metropolitan Water Board, the lining is not watertight and the water is retained by the surrounding clay. The problem was to measure, on an experimental length of tunnel, the degree to which the external load was removed from the lining as the head of water was increased and in the limit to estimate the safe maximum

Cylindrical vibrating-wire load gauges measuring circumferential thrust in tunnel lining

head without risk of collapse of the lining. Here gauges were required which would function satisfactorily for several years, under water, and could be read remotely. One type of gauge had to measure the circumferential load in the lining and another had to measure the change in tunnel diameter under a water head of 140ft.

The load gauge consists, very simply, of a cylindrical steel tube which is compressed axially by the load and changes the frequency of a vibrating wire held along the tube axis. The whole of the load in one tunnel ring is carried by the two load gauges, as shown in the illustration herewith. The effect of external water pressure and of non-axial loads on these gauges is quite small and they have proved quite stable over a period of three years.

The diameter gauge also used a vibrating wire, in a cylindrical watertight case, clamped to one wall of the tunnel, and a wire extends to the opposite wall. This wire is kept in almost constant tension by a long highly compressed spring. Axial movement of the wire relative to the gauge body is transferred through a watertight metal bellows to a tension spring and to the vibrating wire inside the gauge. The sensitivity of the gauge is reduced and the range of movement increased by reducing the stiffness of the spring. Measurement to an accuracy of 0·001in was found possible in the tunnel. The large effect of external water pressure on this gauge is eliminated by connecting it to an air bell anchored to the tunnel invert.

Pore Water Pressure

The laboratory study of soils over the last two decades has led to the development of various experimental procedures, now well known, for the determination of the physical properties of soils both in the laboratory and *in situ*. A particularly valuable and relatively recent development is the technique for measuring pore water pressures, for it gives an insight into what is happening in the middle of a soil deposit that cannot be obtained by any other means. It will be well known to you that when a load is applied to a saturated compressible soil the additional stress is first carried by an increased pressure of the water in the pores. As water drains away the pore pressure dissipates and the additional stress is transferred to the soil grains, resulting in an increase in the shear strength of the soil. Thus by following the change in pore water pressure the increase in strength of the soil can be assessed. This is important in stability problems, such as those that arise in the construction of earth dams, particularly if the available material is fine grained and rather impermeable. A satisfactory field equipment for the measurement of pore water pressures has been developed.

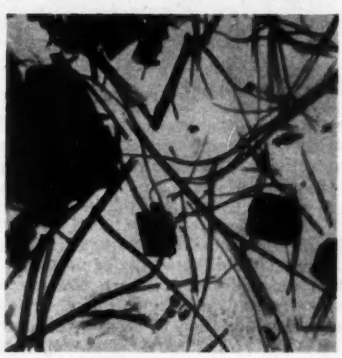
Radiography

Advances in nuclear physics and in X-ray techniques have given new tools which are finding a use both in the laboratory and the field. They are at present largely confined to research, but the tools of research of one day often become the tools of control of a later day. Radiographic examination of metals started with X-rays and later the use of γ-rays developed. X-rays have been less used as an engineering tool in the study of concrete, but one interesting application is in the study of the bond between reinforcing bars and concrete. Bond is a surface phenomenon and the fixing of a strain gauge to the steel interferes with the very object of the study. This difficulty has been got over in the past by the use of tubular reinforcement with optical or resistance wire gauges fixed on the inside to measure the stress distribution during pull-out tests. In the radiographic methods now being developed, for example, by Professor Evans at Leeds, lead markers are fixed in niches in the reinforcing bar and their relative displacement measured by X-ray photography. These photographs also show the slip between the bar and the concrete as shearing action takes place between them. Even this method cannot entirely eliminate interference with the bond, but it appears to reduce it to a minimum.

A more fundamental use of X-rays, of interest at present primarily to the chemist and the physicist, lies in the study of the atomic structure of the compounds present in fresh and hardened cement. But the object of this study, a proper understanding of the nature of the cementing action and of

such basic properties as shrinkage and strength of concretes, is of much importance to the engineer. Already we have important clues to at least one of the causes of shrinkage of set cement. The ultimate crystal units of the prime cementing compound of Portland cement, the hydrated calcium silicate, consist of sub-microscopic fibrous crystals with, on the atomic scale, a layer structure parallel to their length. Water molecules are held as interstitial sheets between these layers to an extent that varies with the state of dryness. As water is removed the layers come closer together and the crystal shrinks at right angles to its length, and when water is taken up the distance between the layers increases again and the crystal expands. There is, in fact, a close parallelism to the shrinkage and swelling of some clay minerals. This is probably not the only cause of drying shrinkage in set cement, but over certain ranges of water content it may be the predominant one.

With the development of the electron microscope, using a beam of electrons in place of light, we can "see" particles much too small to be visible in the normal optical microscope. A picture of set cement is reproduced in the illustration below at a



Electron microscope photograph of set cement

magnification of some 10,000 diameters. The felted lathlike crystals appear to be responsible for the strength development, since other hydrated calcium silicate crystals of closely similar composition are known which do not form this kind of structure and which have no cementing properties. The way to apply this knowledge is not yet in sight, but we well know how increasing knowledge of the fundamental structure of materials eventually becomes a guide to future developments.

Let me return now to matters of more immediate practical interest to the engineer, such as the use of radiographic methods for the examination of materials, such as concrete, *in situ*. Here X-ray techniques are rarely applicable, since for a mass of any substantial thickness the equipment required would be very costly and not suited to use in the field.

As a substitute we can use γ-rays. The γ radiation emitted from radioactive elements is a form of hard X-rays, of smaller wavelength and greater penetrative power. The extent to which they penetrate a material is dependent on its density and its chemical composition and on the energy of the rays. It so happens that over a fairly broad band of energies the absorption of γ rays is little affected by chemical composition as far as the lighter elements, which make up materials such as concrete and soils, are concerned. We have therefore a method by which the density of concrete, or of soils, can be measured *in situ*. The principle of the method is quite simple. A source of γ-rays is placed on one side of, say, a concrete, and the intensities of the incident beam, and of the beam that emerges on the other side, are measured. The Geiger counter, used so much in atomic physics, provides the measuring instrument. Laboratory tests on concretes of known density give the necessary data on the attentuation of the rays, so that from the measured attenuation and the known path length the density of a concrete *in situ* can be derived. The method can be applied not only to hardened concrete, but also to concrete while still in the plastic condition, in contrast, for example, to the ultrasonic methods which cannot be used in concrete before hardening has started. A convenient source of γ-rays is now available in radioactive cobalt (Co^{60}) with which measurements can be made through concrete up to 3ft thick. Penetration of thicker masses is possible, but it requires sources of too great a power to be practicable to handle in the field from the point of view of the protection of the operator. Since variation of the density of a particular type of concrete bears a general relation to uniformity of compaction and to strength, we have here a method of non-destructive test which has been applied, for instance, by the Road Research Laboratory to the study of concrete road slabs. A further application is the use of γ-rays to locate the position of reinforcing bars in concrete members.

Another type of atomic particle, the neutron, enables a measurement of water content to be made. The neutron, that is, the particle of zero charge and of mass equivalent to the nucleus of the hydrogen atom, is scattered by collision with atoms on which it impinges and as a result of this collision the neutron loses part of its kinetic energy and is slowed down. This energy loss is much greater in collisions with atoms of very low atomic weight than in collisions involving heavier elements and, in the process, what are known as "fast" neutrons are converted to "slow" neutrons. In the case of most constructional materials the only element of very low atomic weight present in appreciable quantity is hydrogen in water molecules. If, therefore, a device for measuring slow neutrons is inserted into a material together with a neighbouring source of fast neutrons, and the rate of production of slow neutrons measured, an estimate can be obtained of the moisture content. So far the method has mainly been applied to the measurement of the water content of soils *in situ*, but its application to other materials, such as concrete, is now being studied and may well be of greater importance. There are many purposes for which a knowledge of the moisture content of a material in a structure would be valuable, but only destructive, or cumbersome, methods have previously been available. The neutron method is still at a relatively early stage of development, but we may undoubtedly look forward to improvements that will give a new tool of significance to the engineer.

Cleveland Dam, British Columbia

BY OUR CANADIAN CORRESPONDENT

The Cleveland dam is a water supply structure recently completed in British Columbia, which has permitted a regulated supply of 200 m.g.d. to the Greater Vancouver area. The dam is briefly described in this article, and notes on the principal gates and valves are also given.

As early as 1889, Mr. Henry B. Smith read a paper to the Canadian Society of Civil Engineers which predicted that the River Capilano, north of Vancouver, was a potential source of water for the city which was then in its infancy. He stated that a dam, constructed across the narrow gorge, would provide a water system which would not be surpassed by any on the North American Continent. On Friday, November 19, 1954, there was officially opened the Cleveland dam, on the Capilano River, named after the first chief water commissioner, Dr. E. A. Cleveland, who held office from 1926 until his death in 1952. The dam is shown in the accompanying illustrations.

The water district, which was set up in 1924, has been planning, since its inauguration, a water system that would supply Greater Vancouver and other municipalities. The early surveys indicated that two dams would be required, one on the second canyon of the Capilano, and one on the Seymour River, several miles east of the first river. It was recommended that the first dam, on the Capilano, should be completed by 1940, and the Seymour dam twenty-five or thirty years later. Due to the economic depression of the 1930s, and the second world war, the programme was delayed, with the result that it was not until January, 1951, that tenders were called for the construction of the dam, from the contract specifications and work plans of Dr. Savage, the U.S. consultant. In March of that year, the Gilpin-Nash Company, Ltd. (now Gilpin Construction Company), was awarded the general contract. Other contracts were awarded for materials, machinery and equipment. In March, 1952, the B.C. International Engineering Company was called upon to submit detail design drawings, and working details, Dr. Savage remaining consultant for the project. The area to be flooded covered 655 acres, above the dam site; it was cleared by the spring of 1953.

During the preliminary stage, aerial survey was undertaken, without which the work would have been much delayed. The importance of this work to the project cannot be fully appreciated unless one is conversant with the terrain. One particular point of difficulty, in the survey, was the outcrop of rock over the actual dam site, which defied both aerial and horizontal photographic surveys, as may be inferred from the illustration of the dam. The final solution was the utilisation of an overhead cable arrangement, used with a crane set-up supporting a horizontal levelling rod, which moved vertically and laterally, took direct lateral soundings for measuring elevations, top to bottom. Because of the narrow working space below the overhang, transit sights were taken on the horizontal levelling rod from a point on the canyon wall, and these readings were repeated every 5ft up the canyon.

Concrete was first poured in the dam on October 18, 1952, and the final closure of the diversion tunnel was made in November, 1954. The dam is a gravity structure, 325ft in height, above the river bottom. The total volume of concrete is 142,000 cubic yards, which incorporates 28,000 tons of cement, and 660 tons of reinforcing steels. The excavation was 550,000 cubic yards, plus 110,000 cubic yards of rock excavation. The fill amounted to 270,000 cubic yards. Construction of the dam included 140,000 linear feet of piping for grouting and concrete cooling.

The diversion tunnel was cut through rock and measures 32ft in diameter, with a horseshoe section, 970ft long; it is fitted with four control valves, including 54in Howell-Bunger valves, and 5ft by 6ft sluice gates. Thus the tunnel system permits complete drainage of the reservoir.

The spillway is 80ft in width, between training walls, with a capacity of 43,000 cusecs, the crest being 449ft above high water tide level of English Bay ; the top of the dam is 482ft above the same high-water level. By this dam, spillway and 70ft drum gate, the level of the lake is maintained at 472ft above high water, over an area of 670 acres, giving a total storage of 60,000 acre-feet, and a usable storage of 46,000 acre-feet. The regulated flow is 200 million Imperial gallons a day. The screens for domestic water supply are travelling screens, each 220ft long. There are two 72in domestic water supply outlets. Two 36in gate valves and two 30in gate valves were supplied by the Grinnell Company of Canada for ancillary services exterior to the dam, together with numerous smaller valves for the pumping station below the dam and for the attendant services.

The six 5ft by 6ft square port sluice gates were manufactured by Vivian Engine Works, Vancouver. These valves were designed for a working head of 250ft and some details of their construction are given in the accompanying table. The

Details of 5ft by 6ft Sluice Valves

Face to face, on the sluice body ...	8ft
Opening	5ft by 6ft
Length of hydraulic cylinder	7ft
Height of assembly, approximately ...	25ft
Two lower units : gates of cast steel.	
Four upper units : gates of cast iron.	
Working pressure in cylinder	750 lb per sq in
Stem diameter, 5½in	Lower two units
Stem length, 13ft...	

units were multiple-bolt assemblies, with bodies of ribbed steel. Each unit weighed approximately 54,500 lb. The four cast iron gate units were installed in the dam itself, for the water supply and outlet lines, and the two lower units, in the diversion tunnel, were installed for maintenance and inspection, and for the drainage of the reservoir, in conjunction with the two 54in Howell-Bunger valves.

The 54in Howell-Bunger valves can be used, in conjunction with the two lower sluices, to drain the reservoir. There was a problem in installing them in the diversion tunnel, with its continuous rapid flow. This was overcome by straddling the flow with a flume, building up the plug, with the valve installation, and then constructing the plug around the flume.

The pumping station, at present under construction, will raise the head to the requirements of the upper levels of the communities on the north shore of the Greater Vancouver area.

The drum gate, at the dam, was manufactured by the Vancouver Ironworks, Ltd., Vancouver. It is installed at the crest of the spillway and is 70ft long. The weights are as follows :—

	Tons
Gate only	225
Embedded anchorage	50
Cast iron sectional pier plates...	56

Fabrication of the gate had to be to close tolerances, that along the curved shells being plus or minus ¼in, and the ends had to be square to the pin axis, and made to similar close tolerances. The twenty-two hinge pin holes had to be accurately aligned so that a dummy pin 5½in in diameter, and 16ft long, could be passed, from end to end, by hand. Curved sectional beryllium copper spring seals, rubber backed, were fitted. These seal plates are used to seal the end sections against the cast iron pier plates. Other seal plates are used to seal the rotating drum section at the hinge pins. The drum gate was of the original American Government design. The critical part of the assembly was the line boring of the twenty pin holes, on the hinge section. These held the graphite impregnated bronze bushings. The boring of these was done by a motor-driven boring bar. The success of the shop assembly, boring and accurate fabrication, was due, according to Vancouver Ironworks, to the substantial, level concrete slab, and the installation of a jig of 24in "I" beams, upon which the work was carried out.

Although the original intention was not to shop assemble plate and girder section groups, it was finally decided that this would greatly simplify the field erection and the final accuracy to be obtained on the site. However the shop riveting of the drum gate did entail some complications in the truck haulage to the dam, which had to be routed through the business and residential sections of Vancouver, and over the Burrard Inlet, through the Capilano Park area.

The drum gate was installed, on the crest of the spillway, by its twenty-two gate hinges, to the hinges of the anchor wall, by 2¾in and 2¼in anchor bolts, on the upstream side.

On the downstream side, the gate seat is bolted down by 2in and 1¼in adjusting bolts, with an attached gate seal, and 1in rubber seat, on the gate stop.

One of the difficult points of the work at the dam site was the geological formation of the canyon on the left abutment. Due to the structure of the canyon wall and bed which was of a loose glacial deposit, the result of a buried channel, it was found necessary to use rock and solid fill, and extensive earthworks on this side. To cut the seepage around the abutment, use was made of a blanket of clay, very comprehensive grouting, and cementation of the reservoir wall and bed, above this area. The area of this glacial debris made it impossible to take the reservoir wall to the rock, but a tunnel is being cut to the bed, through the conglomerate, which will act as a drainage tunnel. Another phase of work was the construction of a fish ladder. The fish will be taken the final stage of the lift to the reservoir in a specially designed tank truck.

The dam, in operation, will regulate the flow to about 200 million gallons (Imperial), with a potential supply for 1,000,000 to 1,250,000 people. The dam and other works will cost 10,500,000 dollars.

South side of Cleveland dam ; the central drum gate, which is in the lowered position, can be seen

Cleveland dam nearing completion. The dam is the principal work of a water supply scheme for the Greater Vancouver area

Productivity, Fuel Availability and Its Efficient Use

By K. T. SPENCER

No. II—(*Concluded from Page 891, Dec. 24th*)

All industrial production depends decisively on fuel and power. British industry grew up and became a leading influence in the world in an age of cheap and abundant coal. So far as we in this country are concerned, that cheapness and that abundance have gone for ever. Atomic energy may falsify this prophecy. But as yet we cannot count on its doing so soon. We must face up to a continuing fuel shortage over many years. This paper, one of those presented at a D.S.I.R. Conference on Research and Industrial Productivity, held from November 22nd to 25th, gives facts about the present fuel and power situation and how that situation has come about during the last generation or two. The facts are well-documented, but even now they are not widely enough realised.

Wastage of Coal

For the purpose of studying how coal is wasted, it is convenient to consider the subject under five broad headings :—

(1) The railways.
(2) The domestic fire.
(3) The collieries.
(4) The iron and steel industry.
(5) Industry in general.

In the present paper it is not proposed to enter into the matter of fuel economy in the electricity and gas industries. As suppliers of refined forms of energy from coal, they are of necessity conscious of their own interests in using coal to its maximum advantage. The general trends of their progress in this respect are illustrated in Figs. 5 and 6. In the case of the gas industry, a fair assessment of its progress has not been attempted here, since no account has been taken of the production of coke and by-products. The other five classes of coal users require more detailed study.

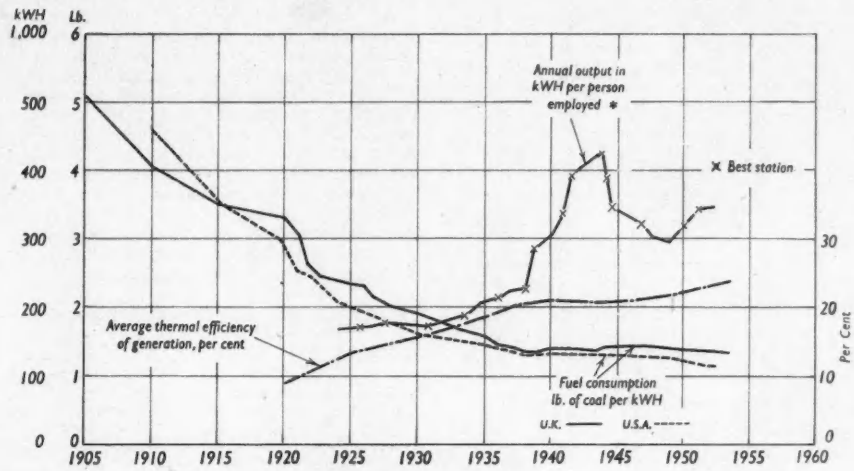
The Railways.—The railways consume roughly 14,000,000 tons of coal a year, almost 13,000,000 tons in the form of good quality, large coal. In 1953, nearly a quarter of all the large coal available went to the railways.

But the efficiency of coal utilisation in locomotives is extremely low and it has shown little improvement over 100 years.

In 1834 some tests were carried out on six locomotives of the Liverpool and Manchester Railway.[7] One of these engines, "Atlas," built in 1832, three years after Stephenson's "Rocket," consumed an average of 537 lb of coke per hour to produce 51 h.p. ; this figure, which corresponds closely to the average performance of all the six engines tested, represents an overall thermal efficiency of something a little under 2 per cent, 10½ lb of coke being converted into 1 h.p. hour. Between 1840 and 1845 the invention of Stephenson's link motion enabled steam to be expanded in the engine cylinders, which doubled the thermal efficiency, bringing this to a maximum of about 3½ per cent. From that date there has been a steady improvement in locomotive boiler efficiency, notably by using continually higher steam pressures and the introduction of superheating. Railway locomotive boilers are reasonably efficient ; "Atlas's" boiler had an efficiency of about 45 per cent ; by 1870, 60 per cent had been achieved ; present day locomotive boilers have an efficiency of the order of 80 per cent. But there has been no corresponding improvement in the performance of the engine of the locomotive, which has remained almost unchanged since 1845.

By 1920 maximum overall locomotive thermal efficiency had reached about 7–8 per cent. At present certain British Railways locomotives can achieve 10–12 per cent, under optimum speed and power conditions.

The above figures all relate to maximum efficiencies achieved under special test conditions and are in no sense a measure of the practical efficiency achieved in every day service. A modern express locomotive on daily long-distance runs achieves an average overall efficiency between 6 and 7 per cent ; a shunting engine averages under 3 per cent. Overall steam locomotive efficiency on British Railways is probably under 5 per cent and there seems no prospect of any substantial improvement in the efficiency of the coal-burning locomotive in its present form. Modern railways electrification, however, can convert the energy in the coal to useful work at the train with an overall average efficiency of 19 per cent.[14] This represents a difference between something over 3½ lb of good coal per horsepower hour on a steam railway system and 1 lb of poor coal per horsepower hour on an electric system.



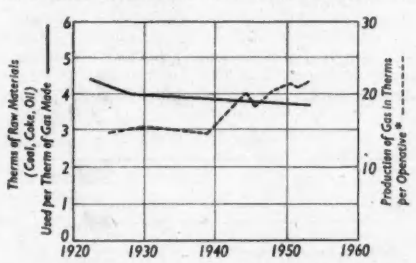
* Refers to total workers in the industry.

Fig. 5—Electricity generation by supply undertakings

The leading authorities in railway engineering and various official enquiries have consistently advocated railway electrification. If it should prove practicable to electrify the whole system some 13,000,000 tons of large coal per annum would be saved at the cost of an increased consumption at power stations of some 5,000,000 tons of poor quality coal.

The Domestic Fire.—The wastefulness of the open domestic grate is already too well known to need discussion. But, apart from its wastefulness, the problem of the open fire will have to be faced if air pollution is to be got under control. That "immovability of the public" has persisted since the problem was recognised in 1856 !

The Collieries.—About 10,000,000 tons of coal a year are burned to raise steam at the pithead. The existing boiler plant is mainly obsolete and inefficient and in 1951, out of 3900 shell boilers in use at collieries, 3400 were hand-fired. Steps have since been taken to convert to mechanical stoking the 500 hand-fired boilers most suitable for adaptation. In spite of the general inefficiency of colliery boiler plant it is often necessary to burn good quality coal in it.[11]



* Operatives include workers on works, plant and distribution.

Fig. 6—Gas manufacture

In addition to purchasing more electricity from the British Electricity Authority the aim of the National Coal Board is gradually to replace all inefficient plant and to build colliery power stations which can burn all the low-grade coal produced. But in the meantime improvements are confined to the installation of mechanical stokers in place of hand-firing where possible, and the installation of water-tube boilers in place of shell boilers. In connection with this problem, the Board has referred to the lack of British types of mechanical stokers and pulverised fuel firing equipment suitable to burn low-grade fuel.[12] The first trials were to be made with a Martin stoker obtained from Germany and capable of burning slurry. It is interesting to note that in 1871 the "Committee on Waste in Combustion," to which reference has already been made, drew attention to pulverised fuel firing and the possibility of its application to the burning of small coal.

The National Coal Board has instituted its own fuel efficiency organisation, which is already achieving results, as shown below :—

Colliery Power Consumption, 1947–1951

	Coal equivalent.* Consumed per ton of output
1947	147 lb
1948	141 lb
1949	135 lb
1950	134 lb
1951	131 lb
1954	114·2 lb

Improvement in eight years 22½ per cent.
* Including estimated coal equivalent of electricity and gas.

However, much remains to be done. Rapid reduction in coal consumption by the collieries cannot be expected.

The Parliamentary Secretary of the Ministry of Fuel and Power[8] has stated that the N.C.B. is taking more electricity from the B.E.A.—2835 million kWh in 1953, as against 1900 million kWh in 1948, because B.E.A. can generate electricity more economically than can the collieries themselves.

The Iron and Steel Industry.—Apart from the electricity and gas industries, the iron and steel industry is the largest single user of coal.

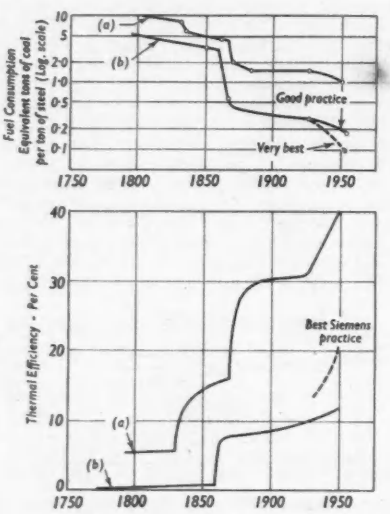
In addition to the 25·9 million tons of coal carbonised in coke ovens in 1953 to provide coke for blast-furnaces, the iron and steel industry consumed 7·4 million tons of coal, and a further 1,000,000 tons of oil.

In iron smelting, coal accounts for nearly half the cost of the final product and, hence, as in the gas and electricity industries, a large amount of work is being devoted to the problems of fuel economy and heat utilisation both by the industry and by the British Iron and Steel Research Association.

In addition to blast-furnace operation, nearly all processes in the manufacture of steel require large amounts of heat. The industry is also aware of the scope for economy in these operations.

M. W. Thring[9] has recently drawn attention to the necessity for fuel economy in the process of steel melting. He traced the trend in fuel consumption in the making of steel from 1750 (Fig. 7), showing that, although there was no great improvement in steel-making between 1880 and 1925, the increasing shortage of fuel since then has led to improvements in operating the open-hearth furnace ; this has resulted in a very considerable improvement in fuel consumption during this period, although no major changes in method have been introduced. At the same time, the reduction in fuel consumption has been greater than the rise in fuel efficiency, because the proportion of hot metal instead of

all cold, used to make 1 ton of steel has increased considerably and this reduces the fuel requirement. Professor Thring also points out that the fuel consumed in making steel will represent an increasing proportion of the cost of the process as fuel supplies become scarcer and, hence, the thermal efficiency of the process will have to be improved. At present the very best practice in



(*a*) All cold metal.
(*b*) 50 per cent hot metal.

Fig. 7—(Above) Theoretical fuel consumption for steel. (Below) Fuel efficiency in iron and steel making

open-hearth operation corresponds to a thermal efficiency of only 22 per cent. On a theoretical basis he has suggested that a thermal efficiency of 50 per cent might be achieved in the Siemens process on cold metal and that a continuous process might even give 70 per cent efficiency.

Industry in General.—Excluding the iron and steel industry, the general manufacturing industries account for over 75 per cent of all industrial coal consumption, or 36·4 million tons in 1953. It is thus obvious that even small economies in this field can produce a large total saving.

It is not easy accurately to assess the improvement in steam-raising performance in industry over a span of years, since similar types of boilers ought to be compared and allowance made for the advent of mechanical firing and advance in design, with the incorporation of feed-water heaters, air heaters and steam superheaters. With this proviso, the general picture is as follows :—

From John Batey's *Steam Boilers and Combustion* a test is recorded of a Galloway boiler of the Lancashire type carried out in 1874, showing an evaporation of 8·77 lb of water per pound of coal actual or 10·4 lb from and at 212 deg. Fah. Up to 1880 only hand-fired boilers were in general service, their efficiencies varying from 50 to 65 per cent. Since the introduction of the water-tube boiler at about this time, the average efficiency of this type has increased to 85 per cent and an overall efficiency of 90 per cent can be obtained. The average efficiency of shell type boilers on full load, however, remains at 65 to 75 per cent. In the light of these figures, it is interesting to note the results of a survey of steam and power usage carried out by the Ministry of Fuel and Power last year. The survey was limited to the larger establishments, industrial and commercial, using more than 2000 tons of coal or its equivalent a year, of which there are approximately 4600 with a total consumption of 63,000,000 tons of fuel a year. These establishments number only 12 per cent of all establishments consuming more than 100 tons of fuel a year, but they account for 75 per cent of the total fuel consumed.

The survey showed that over half the boilers in industry are Lancashire boilers and less than than one-third water-tube boilers ; about half of these boilers are more than thirty years old, more than a quarter being over forty years old. In the cotton industry 74 per cent of all boilers are more than forty years old, nearly all of them being Lancashire boilers. The average efficiency of steam raising by all boilers was shown by this survey to be about 61 per cent. The average evaporation ratio was found to be 6·7 lb per pound, which is less than the test of 1874 which has been mentioned. It would appear that the average efficiency of the shell type boiler has increased by about 10 per cent in the eighty years.

Production by Industry per Ton of Coal Used

In his recent presidential address to the Institute of Fuel, Idris Jones[10] quoted the economists' opinion that even by 1965, on current values, every ton of coal should enable us to produce nearly £100 worth of goods and services. At the present time this figure may be put very roughly at £60, obtained by dividing the value of gross national production by total industrial fuel consumption. This means that the average cost of fuel to industry is about 7 per cent of the value of the goods produced. But this overall figure has very little significance since fuel costs vary enormously between the different industries. This is shown by the following figures :—

Table I.—*Fuel Costs in Industry*

Industry	Value of fuel content in gross product, per cent 1948	1935–7
Pig iron, direct iron castings	44·8	—
Cement	30·4	20·1
Brick and fireclay	18·0	15·1
Iron and steel (melting and rolling)	9·6	13
Glass containers	15·9	8·4
Glass, other than containers	10·2	
Cotton, spinning and doubling	2·3	2·7
Cotton, weaving	1·2	1·3
Woollen	1·5	1·5
Paper and board	7·9	6·2
Motor vehicles and cycles	1·4	0·9

There are all degrees of variation in the values of the goods which can be produced from 1 ton of coal. But the industries in which the cost of fuel amounts to only a small proportion of the value of the product are not necessarily small consumers of fuel. On the basis of 1948 figures, the coal used by industry can be allocated between the various industries as follows :—

Table II.—*Coal Consumed by Industry*

Industry	Per cent of total
Iron and steel	22·5
Textiles	14·6
Clay	10·3
Engineering and other metal trades	9·4
Chemicals	8·3
Food and drink	7·2
Paper	6·6
Cement	4·5
Glass	2·3
Laundries	1·9
China and earthenware	1·4
Rubber	1·4
Lime	1·4
Petroleum and tar	8·2
Allied chemical trades	
Salt mines and works	
Other textiles	
Leather	
Miscellaneous	

It can be seen that the textile industry, which is a low-fuel-cost industry, actually consumes nearly 15 per cent of all industrial coal, whereas cement, which is a high-fuel-cost industry, takes only 4·5 per cent. This emphasises the need for coal saving by all branches of industry.

Any trend in the efficiency of coal utilisation by industry can be discovered only by studying each industry separately and trying to compare present performance with past performance. The specific consumptions in a number of industries have been determined by dividing the total quantity of product by the total equivalent coal consumption for the years 1935 and 1948 or 1953. The total equivalent coal consumption includes coal, coke and oil fuel on an equivalent heat content basis plus purchased electricity in terms of the coal required to generate it. It was not possible to include gas since the figures for 1948 are not reliable and none was available for 1935. Therefore the figures given in Table III below should be treated with reserve.

This table shows that in some industries, e.g. paper and board, bricks and fireclay, cotton, productivity per ton of coal apparently decreased between 1935 and 1948, but that on the whole overall production resulting from the consumption of 1 ton of coal was slightly greater in 1948 than in 1935. It is impossible to estimate the extent to which changes in production per ton of coal have been influenced by the conflicting tendencies of increased mechanisation, which increases energy consumption and fuel efficiency, which reduces it. But in most cases of increased production, the relative use of fuel has decreased, while, where the 1948 production was less than that in 1935, there is a tendency to an increased relative consumption of fuel. Deterioration in coal quality may have had some effect here.

However, owing to the very wide variation in every industry between the performances of the different plants and firms, too definite conclusions must not be drawn from average figures in respect of comparisons between to-day and twenty years ago. Even if firms are grouped under the same process there are a number of subsidiary processes and services which may be carried out under different conditions and to varying extents by the different firms, e.g. sand drying in iron foundries, box-making, &c. One firm may even start its manufacturing process at a higher or lower level compared with another in the same industrial group. For many processes coal consumption figures are dependent on size or output of plant. Conclusive figures are best obtained by comparing the specific fuel consumption of individual firms from one period to another and noting the change.

If specific consumption figures for a particular product are to have any meaning, they must be assessed separately for each manufacturing process, for space heating, for lighting and whatever coal usages there are which are not constant throughout the industrial grouping considered. Furthermore, the size and capacity of plant have to be taken into account and also, in some special cases, the kind of fuel fired.

Allowing that these factors have not been taken into account there are still some striking dis-

Table III.—*Production Per Ton of Coal Consumed in Various Industries*

Product	Authority	Tons of product per ton of coal consumed 1930	1935	1942	1948	1953
Paper and board	A	—	0·73	—	0·51	—
Wallpaper	A	—	1·87	—	1·05	—
Card box	A	—	9·50	—	7·20	—
China and earthenware	A	—	0·54	—	0·65	—
Glass	A	—	0·70	—	1·12	—
Bricks and fireclay	A	—	5·70	—	5·15	—
Cement	A	—	2·90	—	3·10	—
Coal mining	A	—	17·2	—	16·7	—
	B	—	(19·2)*	—	(17·5)	22·0
Biscuits	A	—	1·88	—	2·96	—
Sugar and glucose	A	—	2·64	—	3·06	—
Chocolate and cocoa	A	—	1·35	—	1·22	—
Tea	A	—	19·6	—	36·6	—
Beer	A	—	4·4	—	5·0	—
Tobacco	A	—	1·52	—	1·61	—
Cotton spinning	A	—	0·31	—	0·255	—
Wire manufacturers	A	—	1·95	—	1·94	—
Brass manufacturers	A	—	0·61	—	0·81	—
Steel	C	0·4	—	—	—	0·5
Iron	C	0·8	—	—	—	0·95
Silica and basic refractories	D	—	—	1·61	—	1·76
Fireclay goods	D	—	—	1·93	—	2·60
Salt glazed pipes	D	—	—	1·11	—	1·20
Composite works	D	—	—	2·31	—	2·50
Drain pipes, hollow blocks	D	—	—	2·31	—	4·05
Blue bricks	D	—	—	2·30	—	2·38
Roof and floor tiles	D	—	—	1·78	—	2·50
Common, &c., bricks	D	—	—	8·50	—	10·50
Chemicals (in £ cost of materials per £ cost of fuel)	A	—	£5·75/£ fuel	—	£6·45/£ fuel	—

* Figures in brackets relate to production per ton of *coal only* consumed.
Authorities.—A, Board of Trade Census of Production ; B, Ministry of Fuel and Power Statistical Digest ; C, British Iron and Steel Federation ; D, National Federation of Clay Industries.

crepancies between the quantities of goods produced per ton of coal equivalent within individual industries. This is demonstrated by the following figures compiled by the Ministry of Fuel and Power in 1947 to show, for certain industries, the highest yields, lowest yields and average yields.

TABLE IV.—*Variation Between Best and Worst Yields Per Ton of Coal Consumed in Various Industries*

Industry	Highest yield	Average yield	Lowest yield
Building bricks, tons :			
Continuous kilns...	44·7	8·8	4·8
Intermittent kilns...	16·7	5·0	3·7
Bronze and brassfounding, tons :			
Billets and ingots...	20·0	—	1·7
Castings	2·5	—	0·2
Grain drying, tons	224·0	—	5·6
Iron and steel, tons :			
Rolling and rerolling of ingot ...	15·0	4·0	1·0
Laundry	5·0	1·0	0·4
Beer, barrels	112·0	40·0	18·5
Biscuits, tons	20·0	2·0	1·0

In the matter of fuel consumption within individual industries there is evidently a wide field for investigation, preferably at the level of separate firms.

A detailed analysis of this kind covering more than twenty breweries has recently been carried out by the British Coal Utilisation Research Association.[12] The investigation revealed a variation in fuel consumption of between 3·5 and 12·6 therms per unit of product, the better performances usually being associated with the larger plants. The variation was found to be caused, half by the carrying out of additional processes, and half by variations in the utilisation of heat. On the average about one-and-a-half times more fuel was used than was necessary, some works used nearly three times as much. Wastage occurred mainly in boiler-houses. As a result of the investigation it has been found possible to suggest methods of improvement. All are simple, and if put into effect are expected to save about 200,000 tons of coal per annum.

THE WAY TO ECONOMY

Much has already been done towards promoting fuel economy in industry. Some of the credit can reasonably be claimed by the Fuel Efficiency Branch of the Ministry of Fuel and Power, whose work in this field is now being expanded and intensified by the National Industrial Fuel Efficiency Service. The endeavours of the British Coal Utilisation Research Association have been successfully directed for more than sixteen years towards the more efficient use of coal in home and industry. The Fuel Technology Section of the British Iron and Steel Research Association is constantly seeking methods of reducing fuel consumption and utilising waste heat in that industry. Fuel saving is a primary object of these organisations ; their valuable achievements are well-known and require no restatement from myself.

They have done much, yet more must be done. In his Messel Memorial Lecture of 1952, "The Strategy of Science," Sir Henry Tizard referred to the urgent necessity of making better use of capital resources and scientific manpower, and he drew the analogy of the military commander who never has at his disposal all the reserves he would like but, by strategy, makes the best use of what he has. The fuel front is also of critical importance. There is already a gap in it. Yet some of our reserves are still standing by.

It is to these reserves that I wish to draw attention before concluding. I have in mind the wide scope that exists for fuel saving : first, by raising the general standard of efficiency of fuel-burning plant and, secondly, by ensuring that, so long as it is suitable for the job, the most economical machinery or process is in fact being employed. It is not enough to generate energy efficiently in one stage of manufacture merely to dissipate it in a subsequent stage. I am not thinking primarily here of installations or manufacture in which fuel consumption plays a prominent part, but rather of those many thousands of minor processes, machines and services that are consistently uneconomically run. Their inefficiency may be due to many causes : untrained operators, incorrectly rated motors, failure to install automatic control, lack of financial incentive to renew plant, ignorance of best modern practice, to name a few. Each individual case may appear insignificant but the sum of their inefficiency represents a substantial waste of the nation's resources, and a reserve which must be deployed in this emergency.

To illustrate the scope that exists for improvement along these lines Table V has been compiled, giving some random examples of the kinds of situation that research has already revealed.

THE ROLE OF THE RESEARCH ASSOCIATION

It may be asked : how can this improvement be achieved ?

A characteristic approach to the problem, and one which has already been applied with success, is to test the performance of plant and processes under conditions of normal operation in different factories producing the same type of goods. On this basis comparisons can be formed, and when sufficient experience has been collected, a reasonable standard of fuel consumption can be defined for the particular operation that should be at least attainable by every firm. It is upon the Industrial Research Associations that this task most naturally falls, qualified as they are by their status in industry and by their technical and scientific resources. The work of the British Ceramic Research Association serves well to illustrate this point, inasmuch as fuel consumption can only form a limited part of the interests of this Association. Nevertheless, the extensive programme of exhaustive and fully recorded tests on different types of kiln and drier under normal operation, conducted by this Association, provides a body of information to the industry on the typical performance and fuel consumption of all industrially used pottery firing and drying installations. In addition, guidance has been provided on practical waste heat recovery, efficient steam raising, economical use of electricity, reduction of smoke emission, &c. Its activities have contributed to the greatly improved atmospheric conditions in the potteries and the conversion of many kilns to gas-firing is already saving many thousands of tons of coal annually.

The engineer and management of a pottery factory now have criteria readily at hand by which to measure the performance of their own plant and ample information drawn from practical examples to show in which direction fuel economy may be sought. Similar work has been done by other Industrial Research Associations, e.g. laundries and wool, and in an industry of a different kind, by the National Institute of Agricultural Engineering. But the field is vast, particularly among those power and process-heat using firms in which the cost of fuel has been of minor importance and in which, therefore, research into fuel economy has not been an item of primary interest. The need for continued research in pure and applied science is not questioned, but it is not likely to lead to quick results. The type of investigation advocated here does not require experimental work, but instead the intelligent analysis of available data. For many industries and operations there must be an enormous amount of material readily at hand. Now that the fuel problem is permanently with us, the contribution that the Research Associations can make by providing information and guidance of this type for industry has become of immediate importance.

THE ROLE OF INDUSTRY

However, the lead that can be given by the Research Associations must find an active response in industry ; the one is complementary to the other ; if either fails, both may fail. Nearly all industrial and commercial firms maintain some kind of organisation which studies matters such as times and methods, manpower economy, production programmes, sales, &c. Surely such an organisation could well embrace within its activities the problem of fuel economy. A function of the Research Associations would be to correlate the results reported by firms in the same industry, make comparisons and give advice. It must become an essential feature of good management to take fuel economy under its purview ; management must become fuel minded. The bill for fuel may not appear as a weighty item on the balance sheet of many firms, but its narrow money value belies its true importance. If the supply becomes erratic or independable, financial repercussions can be very heavy. Many businesses have experienced it, but perhaps not all realise that a part of the remedy lies in their own hands.

Make no mistake ! As a nation we are up against it in the fuel and power field. But this has its bright side. It is a challenge of a kind which has always hitherto evoked an adequate response. It is up to everyone of us to see that the same happens now. The challenge is in reality a twofold one in that we are both short of fuel and short of money for capital investment. So we must draw heavily on that other resource upon which Lord Rutherford placed his reliance in another connection and I take the liberty of adapting his words to the present context :—

"We haven't enough fuel so we've got to think."

TABLE V.—*Some Comparative Performances of Machines and Plant as Fuel Users*

Industry	Least efficient	Most efficient
Pottery	Intermittent up-draught oven : 358 therms consumed per ton of earthenware biscuit fired	Electric multi-passage kiln : 17 therms consumed per ton of earthenware biscuit fired
Pottery	Open stillage stove for drying tiles prior to firing: cost per ton of dried tiles=124d.	Tunnel drier using waste hot air for drying tiles prior to firing: cost per ton of dried tiles=27d.
Transport	Average steam passenger train : 10·8 lb of coal per passenger vehicle mile	Average electric passenger train : 4·1 lb of coal per passenger vehicle mile
Transport	Steam branch line train : 0·48 lb of coal per passenger seat mile	Single-deck diesel road coach : 0·021 lb of coal (equivalent) per passenger seat mile
Transport	Steam locomotive freight train : 650 gross tons miles per 10 therms	Diesel locomotive freight train : 4000 gross ton-miles per 10 therms
Mining	Joy continuous miner : 230kWh consumed by machine per 100 tons of coal got	Coal plough : 2kWh consumed by machine per 100 tons of coal got
Agriculture ...	Continuous flow grain drier : consumption in B.T.U. per pound of water evaporated, 6000	Ventilated silo grain drier : consumption in B.T.U. per pound of water evaporated, 1000
Lighting	Gas lamps : efficiency less than 1 per cent... ...	Modern electric lamps : efficiency 20 per cent

The figures given above relate to individual cases of recorded performance and are not necessarily averages.

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Coloured Wall Charts

A NEW form of wall chart manufactured by Office and Factory Equipment (Leeds), Ltd., 7, Templar Chambers, 10, Merrion Street, Leeds, 1, is designed to provide a quick and reliable means of graphically recording information by coloured lines. The chart consists of a frame in which horizontal rows of coloured plastic discs are set between white scales to form continuous lines. Each disc is in the form of a short cylinder and its circumference is divided into five parts coloured black, yellow, green, red and white. Discs can be rotated as required to show any one or combinations of these colours between the scales. Thus, to record information by means of a coloured line, a proportionate number of discs are turned to expose the required length of that colour on the chart.

The scales between the discs are numbered and have a small hole by each number, into which a coloured plug can be set for coding additional information if required. At one side of the chart index slips can be inserted at the end of the lines of discs to show the subject to which they refer.

The wall charts are made in three models with twenty-five lines of seventy-two discs, fifty lines of twenty-four discs arranged in two columns, and seventy-five lines of twenty-four discs arranged in three columns. If required, solid or transparent security covers can be fitted to the wall charts.

Continuous Casting Installation for Stainless and Alloy Steels

BY OUR AMERICAN EDITOR

A continuous slab casting machine designed and built by the Koppers Company, of Pittsburgh, Pennsylvania, recently went into production at the Welland Works of Atlas Steels, Ltd., in Ontario. This plant constitutes the first commercial application of the Rossi-Junghans process to the continuous casting of stainless and tool steels in North America. Other advanced equipment recently installed at the works includes a Linde automatic powder scarfing unit for the conditioning of stainless steel billets, a 20in Sendzimir planetary hot rolling mill and a 20in Sendzimir cold rolling mill.

IT is claimed that a willingness to gamble on new ideas, confidence in the further expansion of the Canadian economy, and the necessity to broaden production with the least amount of capital investment were the major reasons causing Atlas Steels, Ltd., of Welland, Ontario, to install the revolutionary steelwork plant described below. While several Rossi-Junghans machines are in use for the casting of copper, brass and aluminium, the unit at Atlas is the first machine to be installed in North America for the commercial production of stainless and tool steel slabs. The melting shop of the company's works comprises six Heroult electric furnaces which range from 5 tons to 50 tons in capacity. In the past the entire melt had been cast into conventional ingots, which where then cogged on a blooming mill, a 1000-ton press or a 12,000-lb steam hammer. For certain steels, including stainless and tool steel, the continuous casting equipment now facilitates the by-passing of the costly ingot casting process and greatly reduces the number of passes necessary to produce cogged slabs and billets.

Continuous Casting Machine

The continuous casting machine was designed and built by the Koppers Company, of Pittsburgh, Pennsylvania, under the patents of the Continuous Metalcast Company. To date it has been used only in casting stainless steels in 5½in by 7½in billets and 5½in by 21½in slabs, but the machine is capable of casting any size of billet or slab in the general range between 4in by 4in, and 6in by 24in, depending on the size of mould employed. The length of the billets or slabs thus cast is limited only by the availability of hot metal. For practical usage, however, automatic oxygen torches cut the solidified metal into lengths up to 16ft. At the start of the casting operation molten metal from the electric furnaces is poured into a special 35-ton ladle lined with fire and insulating brick and preheated to 2400 deg. Fah. When filled, this ladle is covered and transported by a bogie to the front of the continuous casting machine. Here a crane picks it up, carrying it to the casting floor 31ft above the ground and deposits it in an automatically operated tilting cradle. As the ladle begins to tilt, metal is discharged through a special lipped spout, which holds back any slag and pours into a tundish placed immediately above the mould. This tundish acts as a metal reservoir and pouring box, from which the steel flows through a nozzle into the mould.

A high-velocity oil burner, which is attached to the ladle cover close to the pouring spout, creates a stirring action in the metal when the ladle is tipped for pouring. This stirring action improves the homogeneity of the steel and holds back the slag from the spout. The ability of the high-heat burner to keep the melt at temperature eliminates the need for a holding furnace and other auxiliary equipment. To keep the heat loss at a minimum the burner has to achieve nearly perfect combustion. From the time the metal is poured into the ladle until casting starts the temperature of the steel does not drop more than 100 deg. Fah. A further drop of only 60 deg. Fah. takes place during the entire pouring, period which takes about thirty-five minutes for an average-sized heat.

At the start of the cast the steel temperature varies from 2750 deg. to 2825 deg. Fah., depending on the grade of steel. In general the pouring temperature is kept as low as possible for each grade of steel. The tundish, which is also preheated to 2400 deg. Fah., differs slightly from the designs used in previous Rossi-Junghans machines, in that it is divided into two chambers. The back chamber receives the turbulent metal and a dam holds back any slag or gangue which might happen to flow into it. The second chamber contains the refractory down-spout, through which the molten metal drops into the mould. The flow of metal through these chambers and dams greatly reduces turbulence and delivers a slag-free, precisely positioned vertical stream to the mould directly below. A steady flow rate from the tundish to the mould is obtained by holding the head of the metal in the tundish.

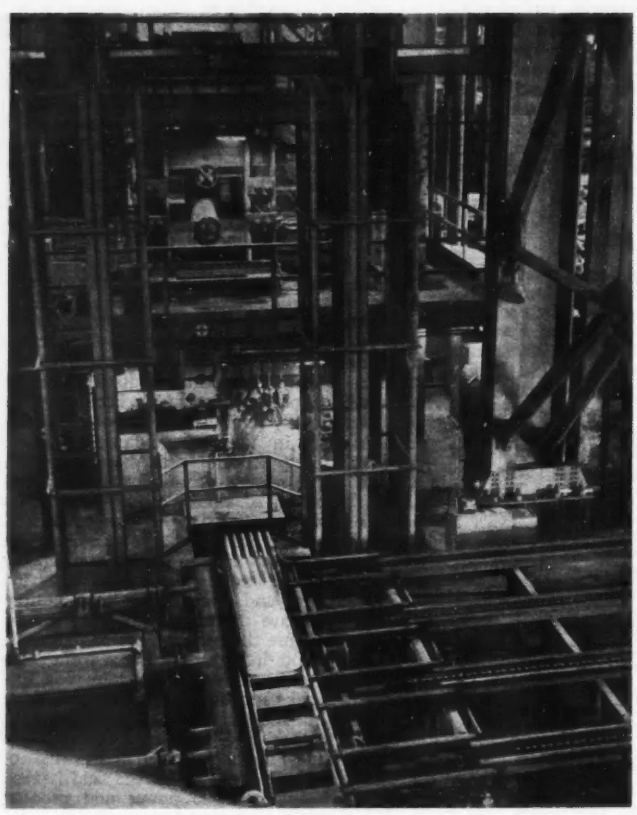


Fig. 1—Front view of ground floor level of continuous casting machine, showing carrier emerging from pit with finished slab

To prevent oxides from forming on the metal surface in the mould, a propane atmosphere is placed on the top of the tundish, around the ladle spout, around the molten stream beneath the tundish and over the metal in the mould. The open-bottom mould of the continuous casting unit is of 6in thick solid copper and is chromium plated on the cavity walls to obtain greater wear resistance. Cooling coils in the interior of the mould carry water at the rate of 175 U.S. gallons per minute. The weight of the moulds varies from 1100 lb to 3000 lb, depending on the section being cast. The important characteristic of all Rossi-Junghans units is the oscillating mould, which moves ¾in downward at the same speed as the casting, but returns about three times as fast. This oscillation of the mould improves the surface finish and prevents metal from sticking to the walls. It also accelerates the heat removal since a new section of wall is constantly being brought into contact with the casting. The main contact occurs in the upper 3½in of the mould, where a steel shell of ⅛in to ¼in thickness is formed.

One of the most interesting aspects of the mould is its short length of 20in, which is said to have contributed much to the success of the operation. The mould walls exert a cooling action on the metal mainly in the upper 2in to 4in ; the casting shrinks from the mould cavity and the rate of heat transfer and solidification fall off sharply below this point. Therefore it was considered desirable to draw the metal out of the mould and to subject it to the cooling action of the water sprays below as fast as possible. A vegetable oil which is fed into the mould during casting provides lubrication between the mould wall and the newly formed billet. Most of the lubricant burns to become a carbon deposit on the mould wall.

The cooling chamber directly below the mould contains the roller apron and the cooling spray system. The roller apron consists of a number of mall rolls placed one above the other. They help to form the casting, guide it to the pinch rolls and work water from the sprays against the steel. The faster the casting rate the longer the roller apron should be. The 9ft long roller apron now being used can handle up to 50 tons of steel per hour. The sprays, which are fitted with replaceable nozzle tips to change the spray pattern, are interspersed between the rolls. It has been found that high pressures and small spray nozzles are desirable to obtain fast cooling action and to break the steam blanket and prevent it from acting as an insulator. The pressure, amount and pattern of sprays used depends upon the type of steel being cast. An average of 225 U.S. gallons per minute are used on the 5½in by 21½in slabs of the austenitic stainless grades while about 50 U.S. gallons per minute are used for tool steels.

Two sets of pinch rolls below the cooling area withdraw the casting and perform a certain amount of forming. At the start of casting a "dummy" bar is threaded through the pinch rolls to the bottom of the mould. The pinch rolls pull the dummy bar and the subsequent casting through the machine. The time from the start of pouring to the start of withdrawal at the pinch rolls is about twenty seconds. The solid casting enters the cutting chamber on the ground floor at a temperature up to 1700 deg. Fah., where it is cut into lengths by two oxy-acetylene torches. The torches are mounted on a carriage which moves vertically downward with the casting during cut-off. The cut-off and discharge is operated on an automatic cycle and when the cut is completed the torch carriage and torches return to their starting position. The casting falls away and is lowered into a discharge pit on a bracket.

So far, most effort at Welland has been put into determining the proper conditions for casting various stainless and alloy steels. However, the company expects to have the unit in full production early next year. The casting rates to date have been conservative. On 5½in by 7½in billets, rates as high as 75in per minute have been obtained, while 5½in by 21½in slabs have been cast at 40in per minute. It has been found that the higher the thermal conductivity of the steel cast, the faster the casting rate can be, and it is expected that 5½in by 7½in billets can be cast at 100in per minute as greater

Fig. 2—Metal flowing from tilted ladle through a tundish into the mould of the continuous casting machine

experience is gained. While the maximum size of heat now being handled is 35 tons, the designers of the machine state it is possible to go to 100 tons with the present equipment.

The surface and internal quality of the continuously cast steels are claimed to be comparable to conventionally processed materials. The steel is clean and free of slag inclusions. It has a high degree of internal soundness, and segregation is held to a minimum because of the rapid cooling and solidification of the metal. A line of weakness which develops at the centre of a rectangular casting, or a point of weakness in the case of a square, can be overcome by proper spraying methods or can be cured in rolling provided that no oxygen enters the metal. There is a possibility of breaking the crystalline structure and the final centre solidification by mechanical means or by an appropriate cooling technique.

Slab Heating Furnace

On delivery from the continuous casting machine, the slabs still retain considerable heat, which facilitates rapid reheating to rolling temperatures. The present procedure is to transfer the hot castings directly to the soaking pits or forge furnaces in the case of tool steels. After as little as one hour of furnace time, the casting is evenly reheated to the proper forging temperature and is then ready for cogging. In the case of stainless steels for strip or sheet production, 5½in by 21½in castings are cogged on the company's 26in blooming mill to 2¼in thick by 11in to 19in wide slabs. These slabs are delivered hot to the automatic powder scarfing unit. A continuous high-head furnace has been installed in line between the continuous casting unit and the planetary mill and is able to reheat the hot slabs in a matter of minutes. Experiments are also being conducted to eliminate any intermediate cogging and to allow the direct rolling of continuously cast slabs on the planetary hot mill.

The high-head furnace was designed and built by the R-S Products Corporation, of Philadelphia, Pennsylvania and mechanically, resembles a roller-hearth furnace. This furnace operates on the principle of a high temperature differential between the heating chambers and the slabs. The heating chambers are fairly small and circular in cross-section, making the furnace well suited for continuous handling of slabs regardless of their length. As the slabs move through the furnace on power-driven rollers, they are completely surrounded by a high-velocity band of hot gases which transfer heat to the slabs by both convection and radiation. Oil burners fire tangentially into the circular heating chamber between the chamber wall and the slab. At no time do the flames impinge on the slabs as they pass through the furnace. The furnace has a normal production rate of 25 tons of stainless steel slabs per hour. The slabs have a maximum thickness of 2¼in and a maximum width of 20in. The slabs are heated to a temperature of 2250 deg. Fah. as they pass through the furnace end-to-end in single file. The furnace has twenty heating sections which are divided among five zones. Zone 1, the entering zone, and zone 2 have five sections, each of which are normally operated at 2700 deg. Fah. Zones 3 and 4 have four sections each which are operated at 2650 deg. Fah. Zone 5 operates at rolling temperature. Each heating section is fired by four oil burners, two on each side of the furnace. The burners on the drive side of the furnace fire above the slab, while those on the opposite side fire below the slab. The spent gases vent from the heating sections into vertical flues above the work rolls and are exhausted to the atmosphere. The burners are capable of developing a total of 13,000,000 B.Th.U. per hour.

Powder Scarfing Unit

Before the slabs are heated for rolling into sheet and strip, they are delivered hot to an automatic powder scarfing unit for surface conditioning. In the past, this method of conditioning stainless steels had been used successfully with single nozzle torches. The process was therefore selected for multiple-nozzle use in an effort to eliminate the costly and time-consuming grinding which is still standard practice in most alloy steel works. Before the process could be adapted for multiple-nozzle scarfing, numerous obstacles had to be overcome.

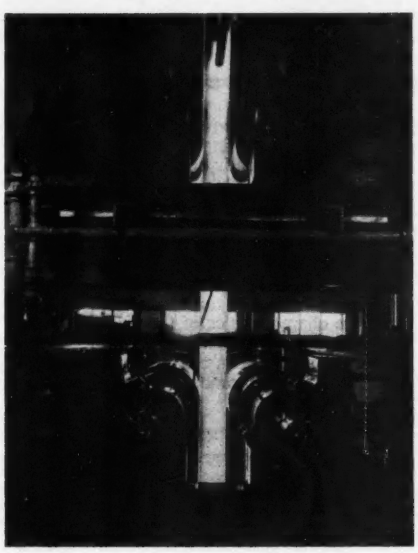


Fig. 3—Slab being guided through the two sets of pinch rolls below the spray cooling section of the machine

One of the biggest problems was the difficulty in dispensing the powdered iron uniformly and at the desired rate in four different directions simultaneously so that equally good results could be obtained on all four sides of the slabs. Another problem involved the removal of the resultant slag to prevent it from rolling ahead of the reaction zone and hindering the progressive scarfing action on the ensuing surface. The scarfing unit was designed and built by the Linde Air Products Company, of New York. The slabs arrive at the scarfing unit at a temperature of about 1900 deg. Fah. The speed at which the slabs are scarfed is variable, but scarfing is normally done at a linear speed of 90ft to 120ft per minute. Scarfing removes about 3 per cent of the metal by weight, consuming about 2 cubic feet of oxygen per pound of metal removed. Oxygen is fed to the nozzles at 30 lb to 40 lb per square inch, and the iron powder flow rate is 5 oz to 10 oz per nozzle per

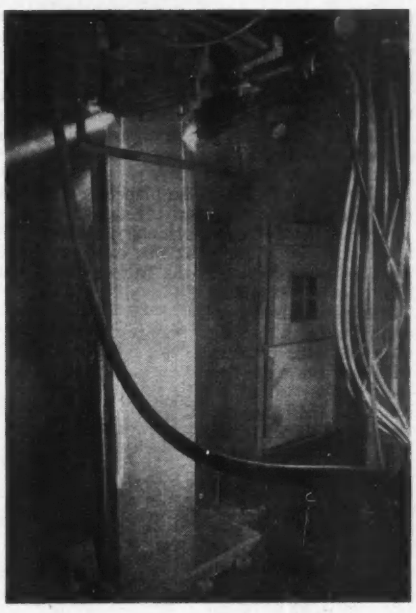


Fig. 4—Slab being cut off by two oxy-acetylene torches which move downward with the casting during cut off

minute under an air pressure of 15 lb per square inch at the pneumatic powder dispenser.

The scarfing unit contains forty-eight scarfing nozzles mounted in four banks. The top and bottom banks each have eighteen slotted nozzles, and the side banks contain six each. The slag resulting from scarfing is washed away by high-pressure cross-fire water jets directed on the slab just at the rear of the scarfing flames. After scarfing, the slabs are cooled on the mill bed and then moved for further conditioning to a "Wheelabrator" machine made by the American Wheelabrator and Equipment Corporation, of Mishawaka, Indiana. In this machine, steel shot is blasted against all four slab sides simultaneously at high velocity to remove any traces of slag remaining from the scarfing operation.

Planetary Hot Mill

Like the continuous casting machine, the Sendzimir planetary hot strip mill has certain advantages for the smaller steel works because of its relatively low cost and its ability to roll small tonnages economically. The design of a similar machine installed at Ductile Planetary Mills, Ltd., Willenhall, was described and illustrated in The Engineer, Vol. 196, page 526. While the British installation can handle widths up to 15in only, the present unit has been designed to take slabs up to 20in wide. It can reduce a 2¼in thick slab to 0·100in thick strip in one pass. As the planetary rolls will not feed themselves, two sets of feed rolls are mounted in the same housing as and immediately preceding the planetary rolls. Each pair of feed rolls is driven by a 35 h.p. motor. Their purpose is to supply a power feed by taking a $^{5}/_{32}$in reduction in each set and to push the slab through the planetary rolls continuously, ensuring that the slabs are butted end to end. The feed rolls are 17¾in diameter by 28in face width and have a normal speed range from 0 to 8·8ft per minute. The first set can be speeded up to 17·6ft per minute to close any gap between slabs. The work of reduction is carried out by forty-eight small

diameter work rolls equally spaced around the circumferences of two heavy back-up rolls, which are driven by a 1250 h.p. motor. The work rolls are 3⅜in diameter by 24½in face width and the back-up rolls are 27in diameter by 24in face width. The back-up rolls are driven in the direction of strip travel at 297·5 r.p.m. The work roll chocks are mounted in cages which, in turn, are mounted on the back-up roll necks and rotate in the same direction as the back-up rolls. The chocks are held in place in the cage by springs which hold the work rolls firmly against the circumference of the back-up rolls. The work rolls thus rotate in the opposite direction to the back-up rolls, i.e. opposite to the direction of the strip travel. All four cages are linked together with synchronising shafts and geared so that the work rolls around the top back-up roll match the work roll around the bottom back-up roll; hence, as the cages rotate, the work rolls will always come together in step and strike the entry side of the slab simultaneously.

Before the slab enters the planetary rolls, the cage assemblies are driven through a double-acting air clutch from a planetary mill drive at a speed of 146 r.p.m. At this cage speed the work rolls are driven by the back-up rolls at a speed of 1130 r.p.m. The clutch is disengaged immediately after the slab enters the planeary rolls and the cages find their proper speed for rolling. The heavy reduction on the slab made by the planetary rolls increases the metal speed during the roll bite from the average entry speed of 6ft per minute to a strip speed of about 100ft per minute. The planetary mill makes a reduction on a slab of approximately 95 per cent in one single pass, and the degree of accuracy in surface finish of the strip is extremely high. The strip from the planetary mill passes to a two-high finishing mill. The rolls of this mill are 22½in diameter by 30in long and the mill is driven by a 250 h.p. motor. A looper-roll is mounted on the entry side of this mill to control strip tension between it and the planetary mill. The distance between the centre lines of the planetary and the finishing rolls is 9ft 6in.

The mill run-out table, which conveys the strip from the finishing mill to the coiler is 78ft long. The mill coiler is a conventional three-roll upcoiler equipped with pinch rolls. The unit is driven by a 35 h.p. motor at variable speeds to suit the rate of strip travel from the mill.

Sendzimir Cold Mill

Following the hot rolling into strip ranging in gauge from 0·062in to 0·187in, the normal procedure is to edge-trim the hot-rolled strip and to anneal and pickle for subsequent cold rolling. The latter operation is performed on a 20in Sendzimir cold reduction mill which is about half the size of the unit installed at the Shepcote Lane Works of Firth-Vickers and Samuel Fox, in Sheffield. Coils of annealed and pickled stock are delivered to the uncoiler of the mill by fork lift truck and pass through a roller levelling unit through the open mill to the rear tension reel. The front coil end is then gripped by the tension reel, the work rolls are put into the cluster, and the strip is reduced as it is coiled on the reel. When the inner coil end is directly over the front tension reel, it is inserted. The coil is then rolled back and forth in either direction to final gauge. During rolling operations, paper may be wound or unwound automatically in and out of the coil on either side of the mill to prevent rubbing and scoring of the coil surface. A set of "Electrolimit" gauges provide the roller with accurate thickness measurements to 0·0001in at all times. The mill proper is driven by a 300 h.p., 600/1000 r.p.m. motor, while the two reel motors are 200 h.p., 300/1200 r.p.m. units. The mill operates at speeds up to 500ft per minute.

The remainder of the new equipment in the company's cold rolling department includes an 18½in by 24in "Treadwell" two-high skin pass mill, a 20in side trimming and slitting line, a 20in levelling and shearing line, and a 20in strip inspection line.

Trans-sonic Jet Engine Training Aircraft

A NEW two-seat, trans-sonic jet engine version of the "F-86" "Sabre" aircraft has completed its initial test flights. The so-called "TF-86" was designed by North American Aviation, Incorporated, for advanced pilot training in high-speed flight, gunnery and dive bombing. The trainer has a tandem cockpit, dual controls and a duplicate instrument panel. Only two modifications to the original "F-86F" airframe were necessary to allow for these additions. First the fuselage section between the nose and wing roots was extended by 63in and, secondly, the 35 deg. swept-back wings were moved forward by 8in. A proven airframe was deliberately used in developing this high-speed trainer, thus providing a ready store of spare parts and trained maintenance personnel. Should the aircraft be put into production, tooling and production facilities now employed for the "F-86" "Sabre" fighter-bomber would be utilised. The "TF-86" is powered by a General Electric "J-47-GE-27" turbo-jet engine developing some 5800 lb of thrust. Most of the performance characteristics of the original "F-86" have been retained. The trainer is rated in the 650 m.p.h. class, has a maximum service ceiling of 45,000ft, and a combat radius of more than 600 statute miles.

North American "TF-86" jet engine trainer

Atomic Power Equipment for Commercial Use

THE GENERAL ELECTRIC COMPANY, of Schenectady, New York, has formed an Atomic Power Equipment Component which will market atomic power equipment for commercial use. This department will engineer, manufacture and sell various types of low-power reactors and reactor systems, heat transfer and cooling system components, safety and remote-handling devices for radioactive material, and other related atomic reactor equipment. The new group was originally organised to supply products and services to the company's Atomic Products Division and will continue to co-operate closely and work in conjunction with that division. In accordance with recently revised regulations, low-power research reactors and components, intended primarily for use by educational, research, medical and industrial organisations, can now be supplied by industry, subject to the regulations of the Atomic Energy Commission. These various components can be integrated into a system to form a complete reactor installation. However, the resulting low-energy reactors can neither be used for producing commercial atomic power nor for making plutonium. Among the possible applications of research reactors are the production of small quantities of radioactive isotopes for use as "tracer" elements in biological and agricultural use, for identification of various elements, and for the education and training of personnel in the field of atomic energy. Research reactors can also be used to study many aspects of power reactor development, such as neutron flux distribution, reactor control-rod calibration and reactor shielding.

It may be recalled that the General Electric Company has long been active in the atomic energy field. In 1940, two physicists at the research laboratory in Schenectady formed one of two teams who independently succeeded in separating uranium 235 from natural uranium. Tests proved this isotope to be capable of the process of fission. In September, 1946, the firm took over the operation of the Hanford Works of the U.S. Atomic Energy Commission. At Hanford, nuclear reactors are used to manufacture production quantities of plutonium for use in atomic weapons. In 1946 also the Knolls Atomic Power Laboratory was established at Schenectady by the company under a contract with the A.E.C. Its objectives were to conduct fundamental research studies, investigations and development work pertaining to atomic energy with particular reference to its application as a useful source of power. For some years the laboratory has been working primarily on the engineering development of atomic power for the propulsion of submarines for the A.E.C. and the U.S. Navy. In February, 1952, the A.E.C. authorised the company to begin the construction of a land-based prototype submarine atomic power plant, which is at present being erected on a 4000-acre site near West Milton, New York. Building the submarine prototype power plant on land makes possible the utilisation of supporting research and experimental test facilities that would not be possible in an operational submarine. The keel of the U.S.S. "Sea Wolf," the submarine which will have an atomic power plant similar to that of the prototype, was laid on September 15, 1953, at Groton, Connecticut.

First Special A.E.C. Award to Dr. Fermi

ENRICO FERMI, Professor of Physics at the Institute for Nuclear Studies, University of Chicago, was recently named as the recipient of the first special award by the United States Atomic Energy Commission. Only a short time after this award, Dr. Fermi died of cancer in Chicago at the age of fifty-three. The American Atomic Energy Act of 1954 authorises such awards for "especially meritorious contributions for the development, use or control of atomic energy." The award to Dr. Fermi, which was recommended by the General Advisory Committee and approved by President Eisenhower, was for 25,000 dollars. The award was accompanied by a citation noting Dr. Fermi's contributions to basic neutron physics and the controlled nuclear chain reaction.

The importance of Dr. Fermi's accomplishments in physics and, in particular, his contributions to the development of atomic energy are well known. The Fermi-Dirac particle statistics, the theory of beta-decay, the Fermi-Thomas model of the atom, neutron-induced radioactivity and a theory of the origin of cosmic rays, are among his experimental and theoretical works. He was awarded, among other honours, the Nobel Prize and has been president of the American Physical Society. In the earliest days of the American atomic energy project Dr. Fermi designed and directed the construction of the first nuclear reactor, and he was in charge of the advanced physics division at the Los Alamos Scientific Laboratory. After the war he served as a member of General Advisory Committee of the A.E.C., besides carrying on his own research into the theory of nuclear forces and the interpretation of meson experiments.

Industrial and Labour Notes

Coal Production and Consumption

The last full working week prior to the Christmas holiday is usually looked upon as one of the best weeks of the year for coal production. This year, the total saleable output in that week fell a little below the output achieved in the comparable week of 1953. The output of deep-mined coal was 4,749,100 tons and of opencast 164,400 tons, making a total of 4,913,500 tons. In the first fifty weeks of this year, ended December 18th, the total coal output was 217,350,400 tons, compared with 216,907,500 tons in the corresponding period of 1953. Deep-mined output this year has been about 1,750,000 tons higher than last, but the production from opencast workings has been more than 1,000,000 tons lower. Coal imports in the first fifty weeks of this year amounted to 2,640,100 tons compared with 506,100 tons in the corresponding period of last year.

The total number of wage-earners on colliery books on December 11th was 704,700, of whom 289,400 were face workers. This means that the number of face workers has declined by about 2500 during the year. In that period there has been very little change in the output per manshift, overall or at the face, but there has been some increase in the amount of deep-mined tonnage lost as a result of colliery disputes. In the first fifty weeks of this year the tonnage lost through disputes has been estimated at 1,194,200 tons, compared with 914,200 tons in the corresponding period of 1953. At the same time, inland coal consumption has increased and in the forty-nine week period ended December 11th totalled 200,542,000 tons, or nearly 6,000,000 tons above the figure for the corresponding period of last year. Export and bunker requirements, at 15,410,000 tons, were 500,000 tons lower than in the first forty-nine weeks of 1953. Total distributed stocks of coal on December 11th were 16,930,000 tons, compared with 18,504,000 tons on December 12, 1953.

This week it has been announced that an agreement has been made between this country and the U.S.A. for the purchase of American coal to the value of over £803,500. It is stated that the coal will be paid for in sterling in the form of various commodities supplied by the United Kingdom to a third country as American aid. This transaction is to take place under the terms of the United States Mutual Security Act, 1954. This Act provides that half the goods sent as aid must be carried in American ships. A few weeks ago the Ministry of Fuel and Power stated that the United Kingdom was spending about 1,250,000 dollars a month on coal, and more recently it was announced that during the next three months this country would import about 100,000 tons of coal from Canada at a cost of about £6 a ton.

Steel Supply Problems

A comment about steel supplies was made last week by Mr. J. L. Brockhouse, chairman and managing director of J. Brockhouse and Co., Ltd., at the company's annual meeting. He said that the company's greatest concern at the present time was the supply of steel in all its forms. Steel mills were quoting nine to twelve months against specification, but the worst factor was that there was no guarantee of tonnage even at that protracted delivery. The practice of the steel mills, Mr. Brockhouse asserted, was to allocate quotas to individual customers from period to period and there was no promise of what that quota would be in any particular period.

Such a state of affairs, Mr. Brockhouse continued, made the rational planning of production an impossibility. The repercussions on the export market were very harmful and export customers were not interested whatever the price might be if protracted and uncertain deliveries had to be quoted. We were told of the increase in steel production, Mr. Brockhouse remarked, but there was no evidence of increased availability. The question of guaranteeing steel supplies to consumers, Mr. Brockhouse urged, was one which must be studied by the British Iron and Steel Federation. The arbitrary methods at present adopted, he said, were a great disservice to the whole of the steel consumer industries. The biggest deterrent to the installation of more efficient plant, Mr. Brockhouse declared, was the constant threat of failure to supply steel.

European Steel Situation

The steel committee of the United Nations Economic Commission for Europe has recently concluded a session at Geneva. It is stated that representatives of all the principal Eastern and Western European steel producing countries participated. During the discussions, there was general recognition of the desirability of increasing trade in steel products, and in iron, chrome and manganese ores, and, according to an official statement, many of the representatives indicated their willingness to "undertake negotiations through appropriate channels to increase this trade."

The committee had before it a series of statistical tables on Europe's internal and external trade in semi-finished and finished steel for the years 1937 and 1951 to 1953. Among other matters, these figures showed that steel exports from Eastern to Western Europe had fallen from 441,000 tons in 1937 to about 75,000 tons in post-war years, the greater part of the latter consisting of exports from the U.S.S.R. to Finland. Exports from Czechoslovakia to Western Europe, however, had shown a significant increase this year, and in recent months, also, pig iron exports from the U.S.S.R. to the United Kingdom had risen. Western European steel exports to Eastern European countries stood at 341,000 tons in 1937, but by 1953 they had increased to 516,000 tons. It is stated, however, that on the basis of statistics for the first half of this year, a substantial decline—of perhaps as much as 50 per cent—in Western European steel exports to Eastern Europe is expected for the whole of 1954.

Nickel Industry in 1954

In a review of the nickel industry, Dr. J. F. Thompson, chairman of the International Nickel Company of Canada, Ltd., has estimated that nickel production throughout the "free" world this year has reached a record figure of about 390,000,000 lb, or approximately 50 per cent higher than the pre-1949 output. Dr. Thompson says that this year's output of the International Nickel Company from its own ores is expected to have reached a record figure of about 275,000,000 lb.

Dr. Thompson goes on to say in his review that government stockpiling acquisitions during this year have absorbed much of the increase in world nickel production and have also required increased diversions from industry. There was, however, a lessened demand upon industry for defence production. The overall result, Dr. Thompson adds, has been that the supply of nickel to industry for civilian applications has been improved. Nevertheless, the review admits that complete satisfaction of civilian requirements of nickel has still not been possible owing to the prevailing government defence and stockpiling programmes.

Clyde Shipbuilding Orders

Before the House of Commons rose for the Christmas recess, the First Lord of the Admiralty was asked if he was aware of the decline in shipbuilding orders on Clydeside. In his reply, the First Lord, Mr. J. P. L. Thomas, said that he was aware that the rate at which orders for new merchant ships were being placed on the Clyde was well below the current rate of output from the shipyards, and that some orders, placed in 1951 and 1952 had been cancelled. But in spite of that, the First Lord continued, on October 1st the Clyde shipbuilding industry had eighty-one ships of 620,000 gross tons under construction and orders for ninety-nine ships of 655,000 gross tons on which work was still to be started. His information was that there had been a slight improvement recently in the rate of ordering.

Railway Wages

At the time of going to press with these notes, the executive committee of the National Union of Railwaymen has stated that it cannot withdraw the strike notices to its members which are timed to expire at midnight on Sunday, January 9th, but that it will participate in the proceedings of the Court of Inquiry which has been set up by the Minister of Labour. The Minister of Labour appointed the Court of Inquiry on Friday last following conversations with the union leaders and members of the British Transport Commission. Sir John Cameron, Q.C., is the chairman of the court, the two other members being Sir Colin Anderson, who is a vice-president of the British Employers' Confederation, and Mr. Harry Douglass, general secretary of the Iron and Steel Trades Confederation. The Court's terms of reference are "to examine and report on the causes and circumstances of the dispute." It began its sittings on Wednesday, and it has been suggested that an interim report at least will be forthcoming before the end of next week.

The conversations between the Minister of Labour and the N.U.R. leaders, prior to the appointment of the Court of Inquiry, did not lead to any very successful conclusion. The union leaders were unwilling to reopen wage negotiations with the British Transport Commission without some assurance in advance that the claim—which is for a full 15 per cent increase on wages ruling prior to December, 1953—would be substantially met. This condition was not acceptable to the British Transport Commission. When the Minister of Labour pointed out that he was left with no alternative but to set up a Court of Inquiry, the N.U.R. executive said that it could not give an immediate decision as to whether it would take part in its examination of the dispute. Its decision to do so was reached last Tuesday.

Earlier last week, the British Transport Commission had made a statement in reply to the arguments which the N.U.R. had put forward. In this statement, the Commission recalled that early in October the N.U.R. had agreed to a wage settlement, apart from footplate men's wages, which had operated from October 4th. When the union asked for discussions to be reopened, the Commission replied that it considered the October settlement as the conclusion of negotiations which had been going on for more than a year. The Commission's statement went on to say that the N.U.R. had since been informed, through the Minister of Transport, that the Commission's attitude was that it would be prepared to discuss through the appropriate machinery and with all speed any particular cases where anomaly was thought to have been created by comparison with the new level of wages for the footplate staff. The Commission was strongly of the opinion that that was the best way to reach a firm settlement for all sections of the railway wages staff. The statement then said that the Transport Commission could not accept the N.U.R. contention that all forms of negotiation had been exhausted, and it reiterated the Commission's opinion that it was open to the union to put forward a fresh claim through the recognised negotiating machinery. The statement concluded by saying that the strike action now threatened by the N.U.R. would be bound to do serious and perhaps lasting harm to the railway industry, at the time when the Commission's plans for reconstruction and revival of the industry were coming to maturity.

Notes and Memoranda

Air and Water

HYDRO-ELECTRIC DEVELOPMENT IN UGANDA.—We learn from Reuter that Sir Charles Westlake, Chairman of the Uganda Electricity Board, recently stated that a survey was being made to determine the most suitable position on the Nile above Jinja for a new hydro-electric station. He said that he thought that a new dam would be needed to reinforce the Owen Falls hydro-electric scheme by 1962.

BRITISH TRANSPORT DOCKS AND WATERWAYS.—With the appointment of general managers for the British Transport Commission's docks and inland waterways activities, the joint board of management constituted temporarily when the Docks and Inland Waterways Executive was abolished in 1953 will cease to exist. Accordingly, Sir Reginald Hill, who was chairman of the Executive from its creation and later chairman of the temporary board of management, is relinquishing his appointment.

MARINE ENGINEERING TRAINING.—We have received from Richardsons, Westgarth and Co., Ltd., Wallsend-on-Tyne, Northumberland, a booklet which is entitled "Your Future is Marine Engineering." It deals with marine engineering as a career and gives details and general information of the five main groups of apprenticeships which the company offers to those wishing to enter the industry. The booklet is illustrated and contains photographs of four engineering centres of the three companies forming the group, and also of various items of engineering interest.

Rail and Road

IMPROVEMENTS AT EUSTON STATION.—Another stage in the improvement programme for Euston Station was completed recently with the underpinning of the buildings alongside No. 15 platform to provide clearance to the widened platform. Removal of a line of steel stanchions which supported two blocks of three-storey brick buildings and a portion of the station roof was necessary; the new columns were set approximately 7ft 6in back. The new supports for the buildings are of heavy all-welded steel beams, positioned in pairs, one close to each side of the old stanchion positions, supported on thirty-one new steel stanchions and cantilevered 7ft 6in to pick up the existing steel girder supporting the walls on the station side of the buildings. The new stanchions are supported on eighty-four bored piles of 18in and 24in diameters with heavily reinforced concrete caps supporting up to five stanchions on a single foundation. The load was transferred into the new stanchions by hydraulic jacks working between the tops of the steel jacking columns and the new beams. The jacking was carried out in six stages to ensure even application of the load and required a total time of approximately two hours for each building. So as to ensure that the lift required to transfer the load was not exceeded, as otherwise there might have been serious damage to the supported structure, electrical limit switches were arranged at the top of each existing stanchion wired to lamps which became illuminated immediately separation took place between the head of the existing stanchion and the existing longitudinal girder. Forty-two jacks were required to handle the load on the larger building and twenty-six on the smaller. In the case of the larger building, the total jacking load was 2124 tons compared with the calculated load of 2090 tons. The heaviest stanchion load was 222 tons. The civil engineer of the London Midland Region, Mr. Taylor Thompson, was responsible for the work. The in-situ piles were constructed by Soil Mechanics, Ltd.; Redpath Brown, Ltd., contracted for the new steelwork, and other work on the site was carried out by the railway's own organisation.

Miscellanea

CHEMICAL COMPANY'S EXPERIMENTAL STATION.—A new experimental station is being built at Woodstock Farm, Sittingbourne, for the Shell Chemical Manufacturing Company. Five single-storey buildings are under construction, which are to be utilised for two laboratories, an administrative block, a workshop, and a garage. The main contractor is Gilbert-Ash, Ltd.

PREVENTION OF SCALE.—Aquastat, Ltd., has published a small brochure which is concerned with the hard water scale problem, and gives a general description of an Aquastat unit, including a table relating capacity in gallons per hour to pipe size. Various case histories are surveyed, typical applications noted, together with some examples of the economies resulting from the employment of the unit.

LECTURES ON POWDER METALLURGY.—A course of ten lectures on "Powder Metallurgy—a Survey of Modern Procedures and Applications," is to be given at the College of Technology, Suffolk Street, Birmingham, on Saturday mornings beginning January 8th. Mr. J. F. C. Morden will deliver these lectures which are intended for technical staff concerned with development, production and marketing in the metallurgical and engineering industries.

EUROPE'S TIMBER INDUSTRY.—The timber committee of the Organisation for European Economic Co-operation has recently completed a study of the European timber market, and has reached the conclusion that the relative stability of the last two years is likely to be maintained. The study points out that the forestry output of Western Europe has always been insufficient to meet all requirements. Before the war the O.E.E.C. countries imported annually from Finland and Eastern Europe over 12,000,000 cubic metres of sawn softwood, over 6,000,000 cubic metres of pit props and about 4,500,000 cubic metres of wood pulp. Supplies from Eastern Europe since 1946 have been considerably below these quantities, although, according to the study, Finland "was not long in regaining a high export level after the war."

LUNCH-TIME FILM SHOWS AT THE BUILDING CENTRE.—The Building Centre, 26, Store Street, London, W.C.1, has organised a series of film shows, starting on January 5th, and held at weekly intervals, each one starting at 12.45 and lasting about an hour. The films on January 5th are about vacuum concrete, and various other topics of concern to the building and civil engineering industries will be shown subsequently, at weekly intervals, until February 23rd.

MR. H. C. MANN.—We have learned with regret of the death, which occurred recently in London, of Mr. Harold Mann, M.I.Mech.E., senior technical representative in the heavy construction department of Newton Chambers and Co., Ltd., Thorncliffe, Sheffield. Mr. Mann, who was sixty-one, served his apprenticeship with the Gas Light and Coke Company, Ltd., at Beckton and Fulham. For many years he was on the staff of Chemical Engineering and Wilton Patent Furnaces Company, Ltd., prior to joining Newton Chambers and Co., Ltd., early in 1945.

CEMENT AND CONCRETE ASSOCIATION TRAINING COURSES.—The Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, has now added to the facilities at its research and training centre at Wexham Place by providing new buildings in which practical work for the training courses can be carried out. The Association has had no little success with its training courses which have now become a permanent part of its work. During 1955, courses for engineers and supervisors will be held covering many branches of concrete technology, including courses on structural concrete (including prestressed work), mix design and quality control, concrete and soil cement road construction, and precast work. Full details may be obtained from the Association at the above address.

MOND NICKEL FELLOWSHIPS.—The Mond Nickel Fellowships Committee has announced the following awards for 1954: Mr. M. Brownlee, of Dorman, Long and Co., Ltd., for the study of British, Continental and American hot and cold metal basic open hearth steel-making with particular reference to furnace design and construction and factors affecting ingot quality; Mr. R. D. Butler, of Imperial Chemical Industries, Ltd., for a study of mineral dressing practice in Great Britain, on the Continent and in the U.S.A. and Canada, with particular reference to the design, layout and operation of small-scale mills; Mr. F. B. Peacock, of Dorman, Long and Co., Ltd., for a study of rolling mill operation and maintenance, with particular reference to soaking pits, blooming mills and the production of universal beams, structural sections and rails, and Mr. A. M. Sage, of the British Iron and Steel Research Association, for a study of the manufacture and fabrication of structural steels in the United Kingdom, Europe, U.S.A. and Canada.

NORTH OF SCOTLAND HYDRO-ELECTRIC BOARD.—The North of Scotland Hydro-Electric Board has announced details of its Gisla (Lewis) hydro-electric scheme (constructional scheme No. 34), which will produce approximately 2,000,000 units of electricity each year. The scheme provides for harnessing the waters of the Gisla River (Amhuinn Gisladh), which flows out of Loch Grunnabhat in the Parish of Uig on the west coast of Lewis, and has a catchment area of some 5 square miles. A diversion aqueduct will utilise a further 2 square miles of an adjacent catchment. A dam, 300ft long and of 27ft maximum height, will be built across the Gisla River. From the dam, water will be led by pipeline 2700ft long, to a power station, with a capacity of 600kW, situated at the mouth of the Gisla River, where it enters Little Loch Roag. At present, there are at Stornoway diesel engine generators with a total capacity of 3600kW which produced 8,600,000 units of electricity in 1953 for the island of Lewis. The Gisla hydro-electric scheme will supply additional power in order to meet the rapid growth of demand. The Board recently published a hydro scheme for Loch Chliostair, in Harris, to supply the electricity network which is being built there. The Harris and Lewis networks are connected by a 33kV line from Stornoway to Tarbert, Harris.

INSTITUTE OF METALS AWARDS.—The council of the Institute of Metals has made the following awards of medals:—The Institute of Metals (Platinum) Medal for 1955 to Dr. C. J. Smithells, Director of Research, The British Aluminium Company, Ltd., Gerrards Cross, in recognition of his services to metallurgical science, to the metal industries, and to the metallurgical profession; the Rosenhain Medal for 1955 to Dr. W. A. Baker, Research Manager of the British Non-Ferrous Metals Research Association, in recognition of his outstanding contributions to knowledge in the field of physical metallurgy, with special reference to the influences of gases and shrinkage on the soundness of cast metals; the W. H. A. Robertson Medal and Premium for 1954 to Professor Hugh Ford and Mr. J. G. Wistreich for their paper on "Problems of the Control of Dimension, Shape and Finish in the Rolling of Sheet and Strip and in the Drawing of Wire"; the medal and premium of fifty guineas, placed at the council's disposal by W. H. A. Robertson and Co., Ltd., are awarded annually for the encouragement of the writing and publication in the Institute's *Journal* of papers on engineering aspects of non-ferrous metallurgy. MSS of such papers should be addressed, in the normal way, to the Secretary, The Institute of Metals, 4, Grosvenor Gardens, London, S.W.1.

Personal and Business

DR. W. D. SCOTT has joined British Tyre and Rubber Company, Ltd., as personal assistant to the managing director.

MR. J. C. GRIDLEY, chairman of Vacuum Oil Company, Ltd., has been appointed a director of Powell Duffryn, Ltd.

MR. T. E. LAING has been appointed a director of British Resin Products, Ltd., Devonshire House, Piccadilly, London, W.1.

MR. H. C. THOMAS, director and secretary of Northern Aluminium Company, Ltd., is being accorded retirement status by private arrangement with the company.

NORTHERN ALUMINIUM COMPANY, Ltd., states that its Birmingham area sales office has been moved to 14, Bennetts Hill, Birmingham, 2 (telephone, Midland 5236).

LLOYD'S REGISTER OF SHIPPING announces the retirement of Mr. J. McMillan, principal surveyor at Hull. Mr. A. W. B. Edwards has been appointed to succeed him.

MR. W. A. TURNER, M.I.E.E., has been appointed principal of the School of Electronics which Automatic Telephone and Electric Company, Ltd., has established at Liverpool.

SCOTTS' SHIPBUILDING AND ENGINEERING COMPANY, Ltd., Greenock, states that Mr. Archibald Alexander is retiring, at his own request, from the board and from his position as secretary of the company.

RANSOME AND MARLES BEARING COMPANY, Ltd., Newark-on-Trent, states that it has signed an agreement with North Eastern Trading Estates, Ltd., for an extension to its factory at Annfield Plain, Co. Durham.

RILEY STOKER COMPANY, Ltd., announces that Mr. A. J. Salter, Midland area branch manager, is now established at a new office at 43, Burton Road, Melton Mowbray, Leics (telephone, Melton Mowbray 495).

JAMES BOOTH AND CO., Ltd., has opened new sales offices at Exchange Buildings, Quayside, Newcastle upon Tyne, 1 (telephone, Newcastle 29731), and at 93, Hope Street, Glasgow, C.2 (telephone, Glasgow Central 2715).

MR. DAVID BROWN, of the David Brown Companies, Huddersfield, announces the acquisition of Tickford, Ltd., Newport Pagnell, Bucks, which builds motor-car bodies. Mr. Ian Boswell will continue as managing director of Tickford, Ltd.

MR. A. G. STEWART, chairman and general managing director of Stewarts and Lloyds, Ltd., has succeeded Mr. G. H. Latham as president of the British Iron and Steel Federation. Sir Ernest Lever, chairman of Richard Thomas and Baldwins, Ltd., and of the Steel Company of Wales, Ltd., has been appointed president-elect of the Federation.

CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., 232, Dawes Road, London, S.W.6, has arranged representation in the British West African territories with the United Africa Company, Ltd., Unilever House, London, E.C.4, with offices in the Gold Coast and Nigeria. Mr. P. J. Darnell has been appointed resident technical representative in British West Africa.

Launches and Trial Trips

FOSNA, tanker; built by Smith's Dock Company, Ltd., for A/S J. Ludwig Mowinckels Rederi; length between perpendiculars 500ft, breadth moulded 69ft 6in, depth moulded 38ft, deadweight 16,300 tons on 29ft 9in draught, service speed 13¼ knots; twenty-seven cargo oil tanks, two main cargo pump rooms, four 500 tons per hour cargo oil pumps, two 100 tons per hour drain pumps; two 250kW diesel-driven generators, two multi-tubular cylindrical boilers, and a Spanner exhaust gas boiler; Kincaid - B. and W. two-stroke diesel engine, 5500 b.h.p. at 110 r.p.m. Launch, December 9th.

WESTERN PRINCE, cargo liner; built by Harland and Wolff, Ltd., for the Prince Line, Ltd.; length between perpendiculars 435ft, breadth moulded 61ft, depth moulded to shelter deck 38ft 6in, deadweight 10,000 tons on 27ft 6in draught; five holds, twelve 5-ton, four 10-ton and one 50-ton derricks, steam deck machinery, three 50kW steam-driven generators; Harland and Wolff-B. and W. single-acting, two-cycle, opposed-piston oil engine, five cylinders, 750mm diameter by 2000mm combined stroke, 110 r.p.m. Launch, December 9th.

TEANO, cargo ship; built by Henry Robb, Ltd., for Ellerman's Wilson Line, Ltd.; length between perpendiculars 260ft, breadth moulded 43ft, depth moulded to upper deck 24ft 9in, deadweight 1800 tons on 17ft mean draught, service speed 13 knots; three cargo holds, derrick complement of 3-ton, 5-ton and 10-ton derricks, steam deck machinery; two 30kW steam-driven generators, triple-expansion, direct-acting, surface-condensing, reciprocating steam engine, cylinder diameters 19½in, 32in, 54in by 36in stroke, Bauer-Wach exhaust steam geared turbine, steam supplied at 220 lb per square inch by two cylindrical multi-tubular, oil-fired boilers. Launch, December 10th.

INNESMOOR, cargo liner; built by Hawthorn Leslie (Shipbuilders), Ltd., for the Moor Line, Ltd.; length between perpendiculars 423ft, breadth moulded 58ft, depth moulded to upper deck 29ft, deadweight 9540 tons, draught 25ft 8¾in, gross tonnage 5574, service speed 13 knots; five cargo holds arranged for carriage of grain, steam deck machinery, derricks to lift 5 tons or 10 tons, two 40kW steam-driven generators; Hawthorn-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m. Trial, December 15th.

British Patent Specifications

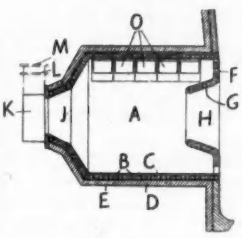
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

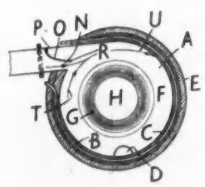
Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

STEAM GENERATORS

718,918. April 21, 1952.—CYCLONE FURNACES, Babcock and Wilcox, Ltd., Babcock House, Farringdon Street, London, E.C.4.

The invention relates to cyclone furnaces in which combustion is effected at a temperature above the ash fusion temperature of the fuel and most of the ash is deposited on and drained from the peripheral wall of the furnace chamber in molten form. In the drawing, the furnace *A* includes a lining of cooling tubes *B* covered on the inner side with refractory material *C* and on the outer side with a layer of heat insulating material *D* and a gas-tight casing *E*. At one end of the furnace chamber is a wall *F* provided with cooling tubes and including an inwardly extending tapering throat *G* forming a gas outlet *H*. At the other end is a funnel-like extension *J*, to which is connected the burner head *K*. The



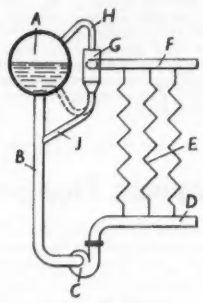


No. 718,918

burner head is provided with a tangential inlet duct *L* for the introduction of the fuel and air mixture and a tangential inlet duct *M* for the introduction of secondary air. Inlets *N* for additional air, disposed side by side, are provided substantially throughout the length of the cylindrical part of the cyclone furnace between the wall *F* and extension *J* and are arranged to direct air with the same direction of whirl as the ducts *L* and *M*. The inlets *N* are set to direct the additional air into the furnace chamber at an angle of 45 deg. to a tangent of the furnace chamber at the place of entry. Each inlet is formed by a plate *O* set within, and extending across the width of an air inlet duct arranged tangentially to the furnace chamber. Each plate is secured to the wall *P* of an air inlet duct and extends towards the furnace chamber so that the edge *R* defines one side of the mouth of the inlet *N* associated with that duct. Each plate is so shaped that each inlet converges towards the furnace chamber and the further air coming from an inlet is directed along a path indicated by a line *S* converging towards another line *T* representing the whirling flame. As shown, the common extension *U* of the two lines contacts the peripheral wall of the furnace chamber only at a substantial distance from the inlet. The slag, which is molten under all working conditions, sinks to the bottom of the furnace chamber and passes through a slag outlet into a secondary furnace chamber, not shown, with which the gas outlet *H* communicates.—*November* 24, 1954.

719,480. February 15, 1952.—DEVICE FOR THE SEPARATION OF A STEAM AND WATER MIXTURE, Heinrich Vorkauf, partner of La Mont Kessel Herpen and Co., Kommanditgesellschaft, Hildesheimerstrasse 195, Hanover, Germany.

The invention relates to a forced circulation steam generator incorporating devices whereby the mixture of water and generated steam is separated, and steam and water flow separately into the steam drum. Referring to the drawing, the boiler water flows from the drum *A* through the connecting pipe *B* to the circulating pump *C* and it is forced through the distributor header *D* into the evaporating tube system *E* which consists of tubes arranged in parallel. The steam and water mixture that is produced in this system flows into the collector header *F* and then into the separator *G*, in which the steam and water are more or less fully separated. The steam that has been released flows through the pipe *H* directly into the steam space of the drum *A*, whilst the remaining water flows through pipe *J* back to the circulating pump *C* or, if desired, as indicated by dotted lines, it may be



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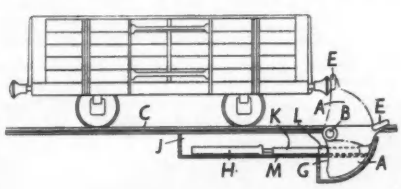
led into the water space of the drum *A*. In contradistinction to steam generators with natural circulation in which the water content of the mixture produced amounts to forty or fifty times the weight of the steam, in forced circulation steam generators the excess of water is only six or seven times the weight of the steam, but as regards the flow velocity the conditions are reversed. In natural circulation boilers the velocity is, at most, 5ft to 10ft per second but in forced circulation steam generators 35ft to 50ft per second are permissible. It is, therefore, an advantage to utilise the high flow velocity to separate the steam and water. Modified designs are also shown in the specification.—*December* 1, 1954.

RAILWAY ENGINEERING

719,528. July 26, 1951.—BUFFER STOPS ON RAILWAY TRACKS, Strachan and Henshaw, Ltd., Whitehall, Bristol, 5. (*Inventor: George Wilfred Grossmith.*)

According to the invention, a buffer stop is retractable into the railway track. Means may be provided to lock the retractable buffer stop in the operative and projected position. Referring to the drawing, a cam member *A* is pivotally mounted on a horizontal shaft *B* below the rail track *C*. A buffer stop or pad *E* is mounted on the cam member so that,



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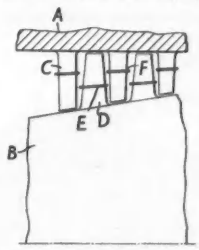
when it is actuated, the stop will be elevated to the dotted position shown, to engage, or be in a position to engage with the wagon buffer. The stops are so disposed that when inoperative no portion of them lies in the path of the wagon. The cam member is provided with a cam surface *G* which, whilst it is curved for the major portion of its length, is substantially vertically below the cam pivot *B* when the member *A* is in the inoperative position. A hydraulic ram *H* is mounted within a chamber *J* below the track so that the ram rod *K* can be projected towards the cam member *A*. The forward or operative end *L* of the ram rod lies on and is guided by a plane surface *M* provided in the chamber. In order to elevate the buffer stop, the hydraulic ram *H* is operated to project the rod, whereupon its operative end abuts the cam surface *G* and causes the cam member to pivot. The buffer stop *E* is thereby elevated into engagement with, or into position to be engaged by, the buffer on a wagon.—*December* 1, 1954.

COMPRESSORS AND TURBINES

719,236. February 6, 1952.—MULTI-STAGE AXIAL FLOW COMPRESSORS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventor: Paul Heinz Walter Wolff.*)

The invention relates to multi-stage axial flow compressors, and to means of improving their characteristics. As shown in the drawing, the stator *A* and the rotor *B* are provided with rows of stator blades *C* and rotor blades *D*, respectively. The rotor blades may be provided with thin platforms *E* between their roots and tips, and/or the stator blades are provided with thin platforms *F* between their roots and tips, these platforms being nearer to the roots than to the tips. The shroud ring formed by the platforms *F* of the first row of stator blades *C* may be made to extend upstream into the compressor inlet where the air flow is affected by the flow pattern in the blading. As shown, the shroud platforms *F* on the stator blades and the rotor blades of consecutive rows are in alignment with one another, but radially offset relative to each other. Where the collapse of flow occurs mainly in the stator blades *C* (depending on the type of blades used), and the radial flows are set up in or near the stator blades, it may be sufficient to have the shroud rings *F* extending approximately over the axial length of the stator blade rows *C* only. Conversely, it may be sufficient to extend the shroud rings *E* over the rotor blades *D* only, when the radial flow occurs mainly in the latter. The blade rows *C* and *D* may be considered as those of the lowest pressure stages of a purely axial flow multi-stage compressor, or as those of a combined axial—and radial—flow compressor in which several axial flow stages are provided before the inlet into the radial flow stage. Accordingly the term multi-stage axial flow compressor includes a combined axial—and radial—flow compressor having several axial flow stages.—*December* 1, 1954.



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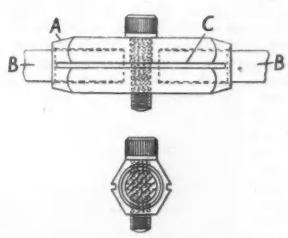
ELECTRICAL ENGINEERING

719,583. July 2, 1952.—ELECTRICAL CONNECTORS, Astral Switchgear, Ltd., Alma Road, Enfield. (*Inventor: Jack Richardson.*)

The busbar connector comprises a tubular element or ferrule *A*. At each end the element is axially bored to provide an easy fit on the busbars *B*. The recesses extend part way through the element so as to leave a central solid portion. Along the element are slots *C* extending nearly to the ends. The thickness of the slot provides an ample clearance



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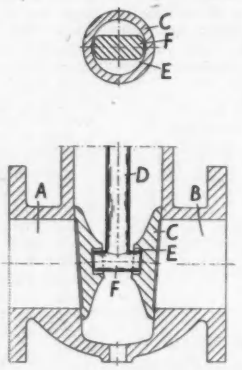
so that the parts on either side may be drawn together. For this purpose a hole extends through the centre of the element, the hole on one side being tapped, that on the other side providing a clearance. A screw is threaded into the hole and on the busbars *D* being inserted in the axial recesses the screw is tightened for the parts on each side of the slot to be drawn into gripping contact. If desired, more than one tightening screw may be provided.—*December* 1, 1954.

VALVES

719,306. July 5, 1951.—SLUICE VALVES, Eric Olof Thornros, Floragatan 7, Stockholm, Sweden.

The invention relates to a sluice valve provided with an operating rod which co-operates with two separate valve closure members. The valve is specially applicable to use in piping for hot fluids. Referring to the drawing, the valve body has an inlet *A* and an outlet *B*. Circular plate-shaped valve closure members *C* have an operating rod *D* and are arranged to engage seatings round the inlet and outlet. The valve closure members have in their backs circular recesses *E* for studs formed by the arms of a crosshead *F* at the lower end of the operating rod. The studs have plane end surfaces which, when the valve is closed, lie against the bottom surfaces of the recesses *E*. These end surfaces of the studs together form a wedge which jams the closure members against the seatings. An allowance for play is made between the studs and the side walls of the recesses. The studs are oblong in transverse cross section, so that play between the studs and the valve closure members in a direction transverse to the movement of the operating rod is limited to a minimum while sufficient play is obtained for movement outwards of the wedge-shaped crosshead *F* when the valve is to be opened. Jamming of the valve, on opening,

is obviated or mitigated as a result of this play. When shut, the axis of the arms or studs is slightly below the centres of the recesses *E*. The drawing shows the position of the parts when the operating rod has been raised somewhat and the wedging effect on the valve closure members has been released. When the rod is lifted up further the members *C*



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follow the inner plane surfaces of the upper part of the valve body. The members rotate about the studs formed on the crosshead *F* so that substantially uniform wear will take place on the surfaces of members which, in the closed position, abut the seatings surrounding the inlet and outlet.—*December 6, 1954.*

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GLOSSARY OF TERMS AND NOTATION FOR TOOTHED GEARING

No. 2519 : 1954. Price 6s. This glossary, in addition to giving definitions for terms commonly used in all applications of toothed gearing, also gives a standard notation which includes the symbols required for use in the theory and practice of gear engineering. The terms and definitions are grouped in eight sections and there is a complete index.

One section gives definitions for all the com mon errors in gear cutting. Another section giving geometrical definitions has been made as short and as concise as possible, but the basic definitions, on which the theory depends, together with the twenty pages of illustrations, will be of considerable interest and value to students. It is intended that, in future, gear standards will include only the special terms and symbols which are applicable to that particular kind of gearing which forms their subject.

RECOMMENDATIONS FOR THE USE OF BITUMEN EMULSION FOR ROADS

No. 2542 : 1954. Price 4s.—These recommendations have been prepared to replace B.S. 433 : 1931, which has been withdrawn. They establish general rules of procedure in the use of bitumen emulsion for road construction and maintenance. The standard covers the application and use of bitumen emulsion for preparing and treating road surfaces carrying wheeled and foot traffic, and also includes recommendations regarding contractual considerations and equipment. It does not cover the use of bitumen emulsion for such purposes as soil stabilisation, roofing work, &c. The standard is divided into eight parts.

Part 1 deals with the general aspects of the use of bitumen emulsion, and Parts 2 to 8 deal with the following subjects : surface dressing ; grouting ; retreading ; premixing ; mist spraying ; tack coating; concrete curing.

BIRMINGHAM ENGINEERING CENTRE.—The Birmingham Exchange and Engineering Centre has stated that, since it was opened in June, the attendance of visitors has averaged 5900 a month. Up to the end of November, 664 specific inquiries had been received, about 50 per cent of which were passed on to engineering firms exhibiting at the Centre.

Contracts

A CONTRACT for the construction of a sea wall and repairs to a concrete apron between New Clee and Cleethorpes has been let by British Railways to Clugston Cawood, Ltd., 16, High Street East, Scunthorpe, Lincs. A removable timber flood barrier is also to be provided in the vicinity of Suggits Lane level crossing.

HUMPHREYS AND GLASGOW, Ltd., has received an order for the complete pit top decking and mine car circulating plant at Glyncorrwg South Pit, No. 2 area of the National Coal Board (South Western Division). The plant will be hydraulically operated throughout and will include decking lifts and car cleaning plant of advanced design. The contract includes the buildings and structural steelwork.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Jan. 6th.—MERSEYSIDE SECTION : College of Technology, Byrom Street, Liverpool, 3, "Some Interesting Applications of Electronics to Photography," D. M. Neale, 7 p.m.——N.W. SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, "Problems in the Design and Production of Car Radio," discussion opened by C. L. Caiger, 7 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Jan. 11th.—Church Institute, Hull, Presidential Address, "Some Uses of Solvents," J. B. Moller, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Wed., Jan. 5th.—EDINBURGH CENTRE : Manor Club, 12, Rothesay Place, Edinburgh, 3, "Street Lighting Lantern Design," T. M. Christie, 7 p.m.——NEWCASTLE CENTRE : Liberal Club, Pilgrim Street, Newcastle, Presidential Address, E. C. Lennox, 6.15 p.m.——SWANSEA GROUP : S. Wales Electricity Board's Demonstration Theatre, The Kingsway, Swansea, Informal Meeting, Three Papers followed by a Discussion, 6.30 p.m.

Thurs., Jan. 6th.—CARDIFF CENTRE : S. Wales Electricity Board's Demonstration Theatre, The Hayes, Cardiff, "Studies in Interior Lighting," J. M. Waldram, 5.45 p.m.——GLASGOW CENTRE : Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "High Bay Lighting," F. Jones, 7.30 p.m.——NOTTINGHAM CENTRE : E. Midlands Electricity Board, Smithy Row, Nottingham, "Recent Studies in Glare," R. G. Hopkinson and P. Petheridge, 6 p.m.

Fri., Jan. 7th.—BATH AND BRISTOL CENTRE : Royal Hotel, Bristol, "Studies in Interior Lighting," J. M. Waldram, 6.15 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Jan. 4th.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, "The Writing and Presentation of a Technical Report for a Non-Technical Board of Directors," W. J. Dickie, 7 p.m.

Wed., Jan. 5th.—SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, "Industrial Instrumentation," C. M. V. Benwell, 7.30 p.m.

Thurs., Jan. 6th.—PETERBOROUGH BRANCH : Campbell Hotel, Bridge Street, Peterborough, Ten-minute Papers by Members, 7.30 p.m.

Fri., Jan. 7th.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Gas Turbines in Industry," J. R. Needham, 7.30 p.m.

INSTITUTE OF METALS

Tues., Jan. 4th.—OXFORD LOCAL SECTION : Cadena Cafe, Cornmarket Street, Oxford, "Titanium," P. Litherland Teed, 7 p.m.

Thurs., Jan. 6th.—BIRMINGHAM LOCAL SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, a debate on the motion, "This house considers that, at the present stage of industrial metallurgy, empirical methods of research are more profitable than those employing the fundamental approach," proposed and seconded by D. V. Atterton and J. Crowther, opposed and seconded by A. R. E. Singer and G. Parkin, 6.30 p.m.——LONDON LOCAL SECTION : 4, Grosvenor Gardens, London, S.W.1, "Some Aspects of Twinning and Kinking in Metals," A. H. Cottrell, 6.30 p.m.

INSTITUTE OF REFRIGERATION

Tues., Jan. 4th.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Ground and Airborne Equipment for Cooling Aircraft Cabins," N. Anderson, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Jan. 4th.—N.W. CENTRE : Victoria and Station Hotel, Preston, "Two-Speed Axles," 7.30 p.m.

Wed., Jan. 5th.—EASTERN CENTRE : Lion Hotel, Cambridge, "Drilling Equipment for Seismic Oil Prospecting," B. A. England, 7 p.m.

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS

Tues., Jan. 11th.—Institution of Electrical Engineers, Savoy Place, London, W.C.2, "The Design and Application of Tractor-Mounted Loaders," J. C. Bamford, 2.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 4th.—WORKS MEETING : Great George Street, Westminster, London, S.W.1, "The Reconstruction of Deptford Creek Bridge," F. M. Fuller and J. N. C. Couper, 5.30 p.m.——N.W. ASSOCIATION : Reynolds Hall, College of Technology, Manchester, "Some Applications of Reinforced Concrete in the Gas Industry," T. Andrews, 6.45 p.m.

Wed., Jan. 5th.—N.W. ASSOCIATION : 9, The Temple, 24, Dale Street, Liverpool, "Some Applications of Reinforced Concrete in the Gas Industry," T. Andrews, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Jan. 3rd.—S. MIDLAND CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on "Sandwich Courses," opened by W. H. Taylor, 6 p.m.

Tues., Jan. 4th.—S. MIDLAND CENTRE : Town Hall, Birmingham, Faraday Lecture, "Courier to Carrier in Communications," T. B. Terroni, 6 p.m.——N. MIDLAND CENTRE : British Electricity Authority, 1, Whitehall Road, Leeds, 1, "The Co-ordination of Insulation of High-Voltage Electrical Installations," J. S. Cliff, 6.30 p.m.——MEASUREMENTS AND RADIO SECTION : Savoy Place, London, W.C.2, "Equipment of Instrumental Accuracy for Recording and Reproduction of Electrical Signals Using Cinematographic Film," H. McGregor Ross, 5.30 p.m.

Wed., Jan. 5th.—SUPPLY SECTION : Savoy Place, London, W.C.2, "The Economic Selection of Cooling Towers for Generating Stations," G. F. Kennedy and P. H. Margen, "The Application of Friction-Heat Transfer Correlations to Cooling Tower Design," P. H. Margen, 5.30 p.m.

Thurs., Jan. 6th.—ORDINARY MEETING : Savoy Place, London, W.C.2, "Problems of Hydro-Electric Design in Mixed Thermal-Hydro-Electric Systems," T. G. N. Haldane and P. L. Blackstone, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 31st.—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, INDUSTRIAL ADMINISTRATION AND ENGINEERING PRODUCTION GROUP : "Development of the Lost-Wax Process of Precision Casting, 1949–1953," J. S. Turnbull, 5.30 p.m.

Tues., Jan. 4th.—BIRMINGHAM A.D. CENTRE : James Watt Memorial Institute, Great Charles Street, Birmingham, "Vehicle and Road Illumination," J. H. Nelson, 6.45 p.m.

Wed., Jan. 5th.—HYDRAULICS GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, Discussion, "Hydraulic Transmission : The Relative Advantages of Oil and Water," 6.45 p.m.

Fri., Jan. 7th.—GENERAL MEETING : 1, Birdcage Walk, Westminster, London, S.W.1, "Impact Torsion Experiments," and "Experiments on the Effect of Rate of Testing on the Criterion of Failure of Certain Mild Steels," N. G. Calvert, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Jan. 5th.—NORWICH SECTION : Assembly House, Theatre Street, Norwich, "Fuel Efficiency in the Factory," E. J. Tickner, 7.30 p.m.——NOTTINGHAM SECTION : Victoria Station Hotel, Nottingham, "The Human Aspect in Production Planning and Control," B. G. L. Jackman, 7 p.m.——WOLVERHAMPTON SECTION : Anchor Hotel, Wednesbury, "Lock Design and Manufacture," C. G. Smith, 7.15 p.m.

Thurs., Jan. 6th.—READING SECTION : Great Western Hotel, Reading, "Work Measurement," T. U. Matthew, 7.30 p.m.——S. WALES AND MONMOUTHSHIRE SECTION : S. Wales Institute of Engineers, Park Place, Cardiff, "Standardisation in the Process Industries," E. W. Greensmith, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Jan. 4th.—MIDLAND COUNTIES BRANCH : Midland Institute, Birmingham, "Load Factor Methods of Design of Reinforced Concrete," F. G. Thomas, 6 p.m.——N. IRELAND BRANCH : College of Technology, Belfast, "Reinforced Concrete Portal Frames in Northern Ireland," J. D. Boyd, 6.45 p.m.

Fri., Jan. 7th.—LANCASHIRE AND CHESHIRE BRANCH : College of Technology, Manchester, "The Present Situation on Retaining Wall Design," P. W. Rowe, 6.30 p.m.——WESTERN COUNTIES BRANCH : University of Bristol Geology Lecture Theatre, Bristol, "Recent Bridge Works in Bristol District," H. G. Lakeman, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 31st.—POPULAR FILM EVENING : Pepys House, 14, Rochester Row, London, S.W.1, "Sweet Thames Run Softly," "West Country Journey," "Spinning Wheels," 7 p.m.

Wed., Jan. 5th.—MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Power Press Safety," J. H. Price, 7 p.m.

Fri., Jan. 7th.—Pepys House, 14, Rochester Row, London, S.W.1, Film Evening, 7.30 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Jan. 7th.—Engineers' Club, Albert Square, Manchester, "Engineering Practice in the Gas Industry," T. Andrews, 6.45 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Jan. 4th.—N.W. BRANCH : College of Technology, Sackville Street, Manchester, "Some Applications of Reinforced Concrete in the Gas Industry," T. Andrews, 6.45 p.m.——MIDLAND COUNTIES BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, "Load Factor Methods of Designing Reinforced Concrete," F. G. Thomas, 6 p.m.

Wed., Jan. 5th.—N.W. BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "Some Applications of Reinforced Concrete in the Gas Industry," T. Andrews, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Jan. 4th.—SECTION LECTURE : 4, Hamilton Place, London, W.1, "Recent Advances in the Knowledge of Transonic Air Flow," C. H. E. Warren, 7 p.m.

Thurs., Jan. 6th.—MAIN LECTURE : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Lecture to Young People, P. G. Masefield, 3 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Jan. 3rd.—ORDINARY GENERAL MEETING : 12, Great George Street, Westminster, London, S.W.1, "Valuations for the Purposes of the Town and Country Planning Act, 1954," 5.30 p.m.

END OF VOL. 198

The Engineer

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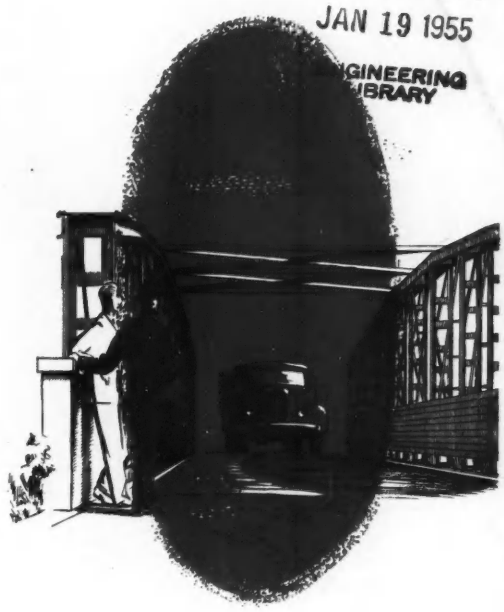

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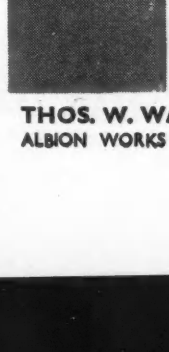

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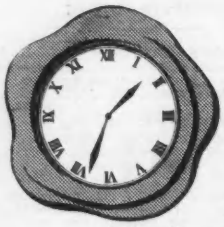

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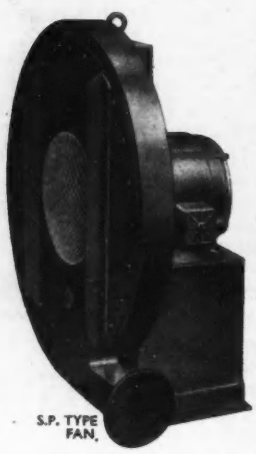

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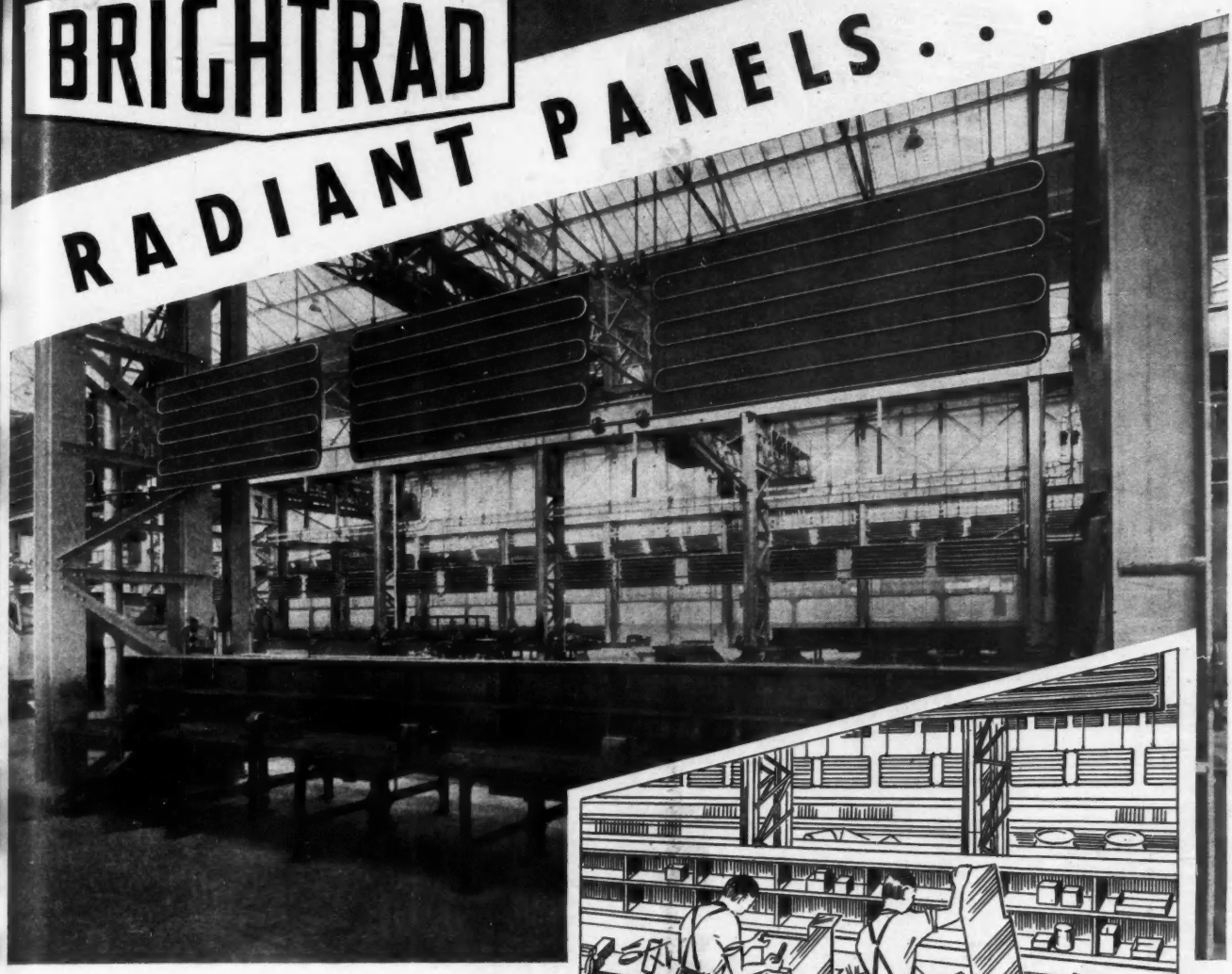

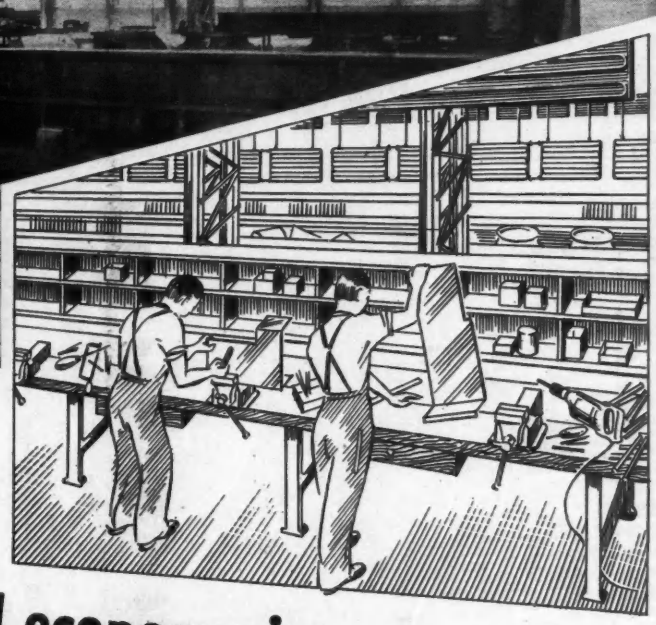

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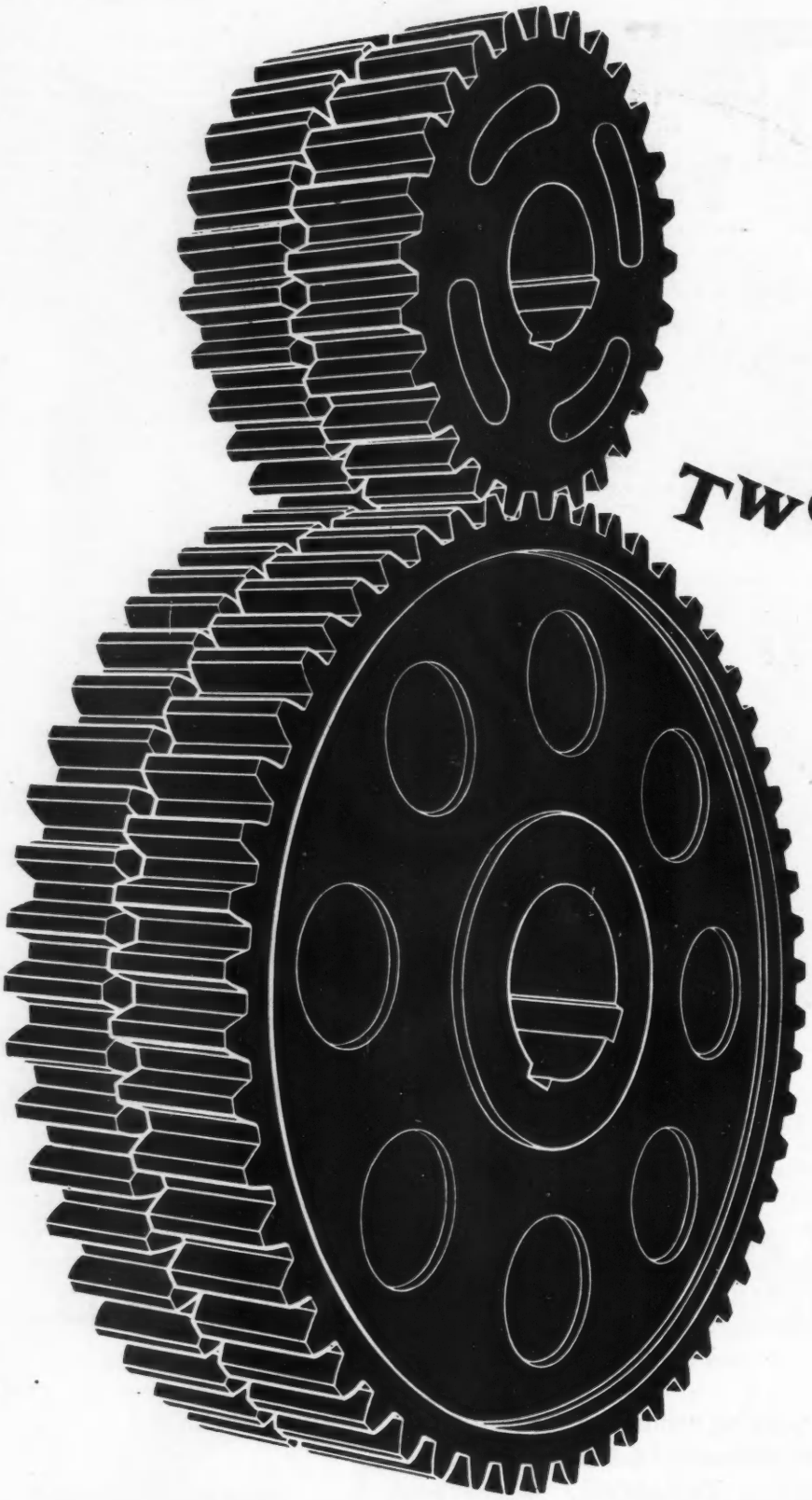

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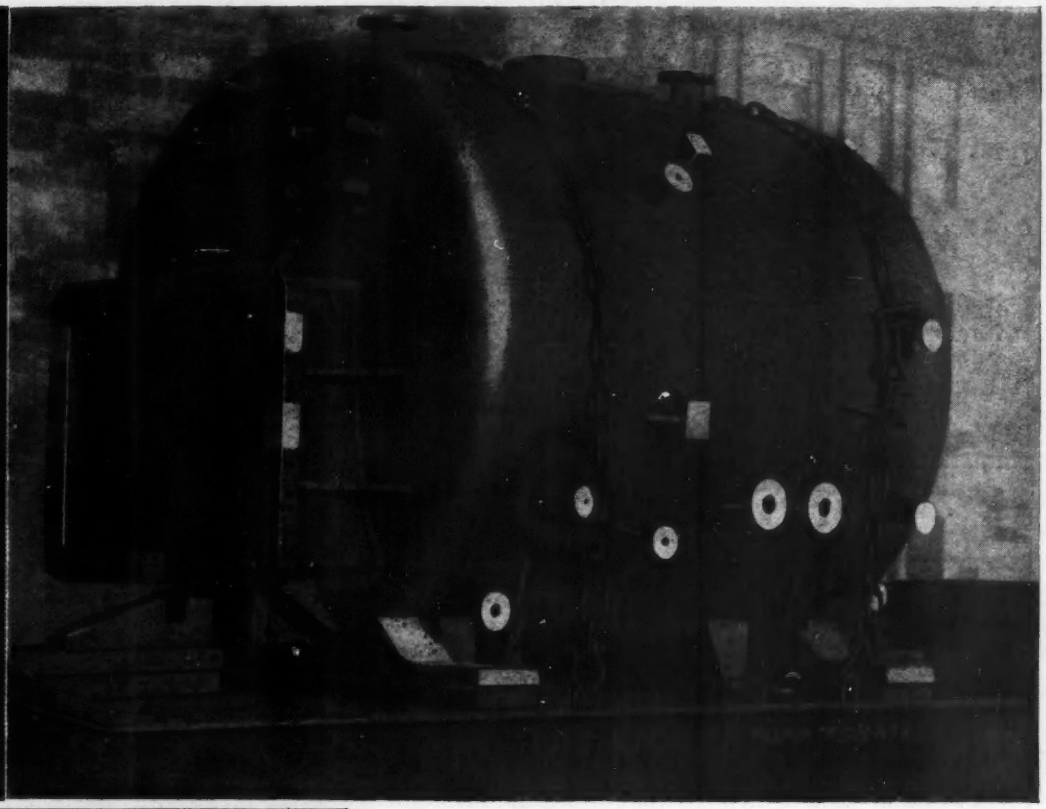

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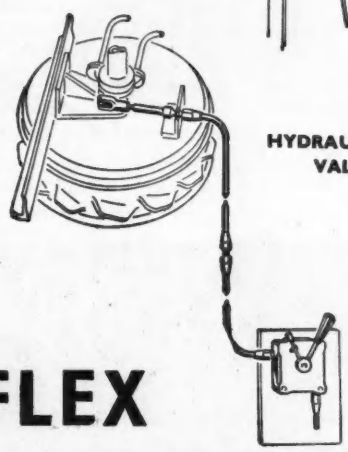

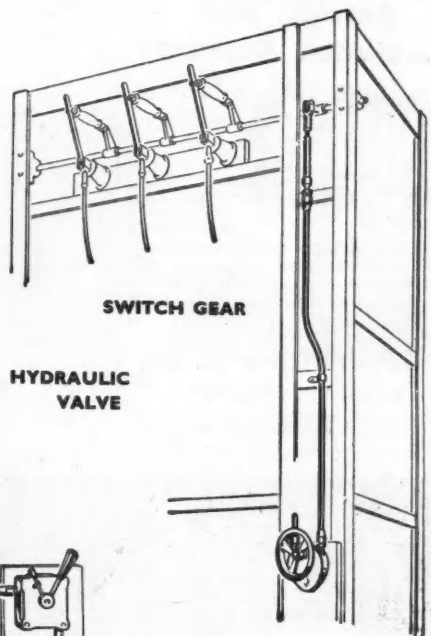

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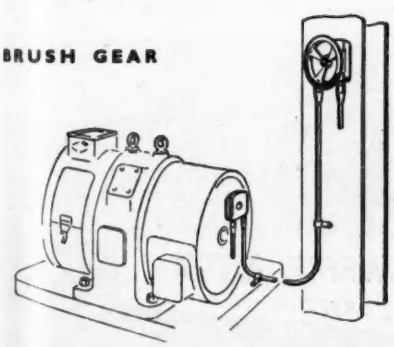

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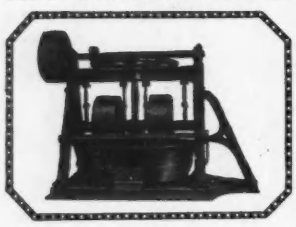

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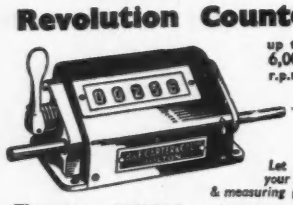

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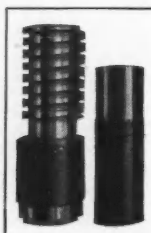

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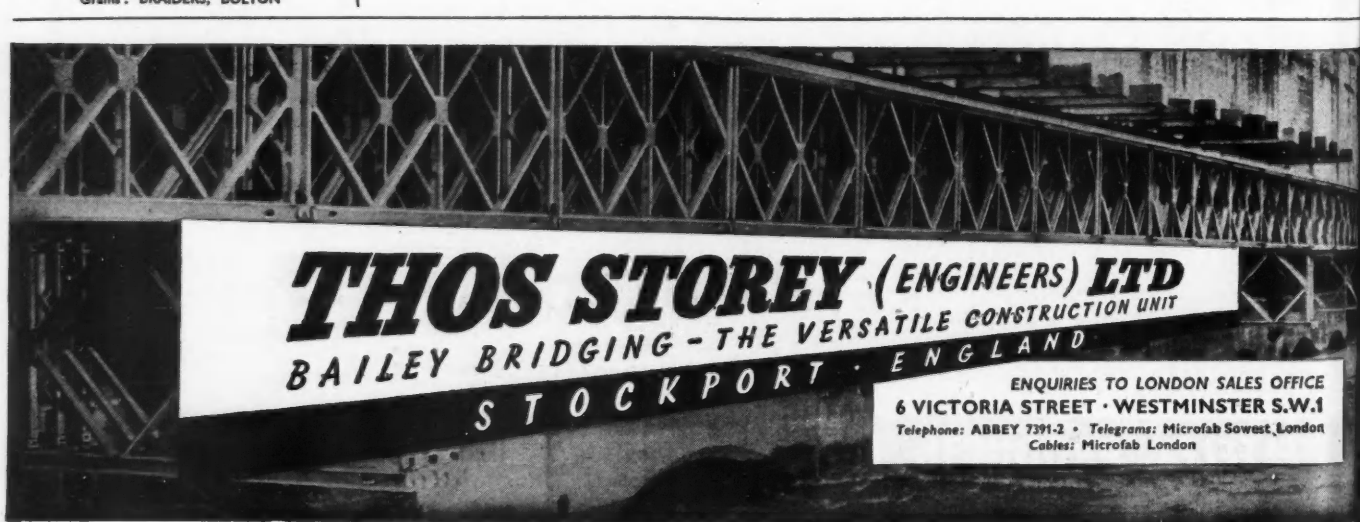
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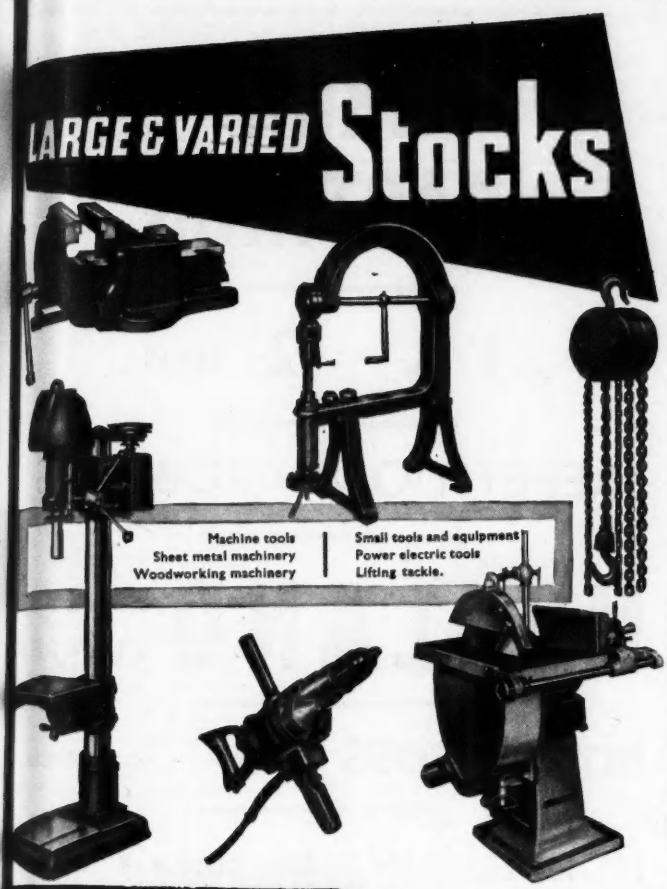

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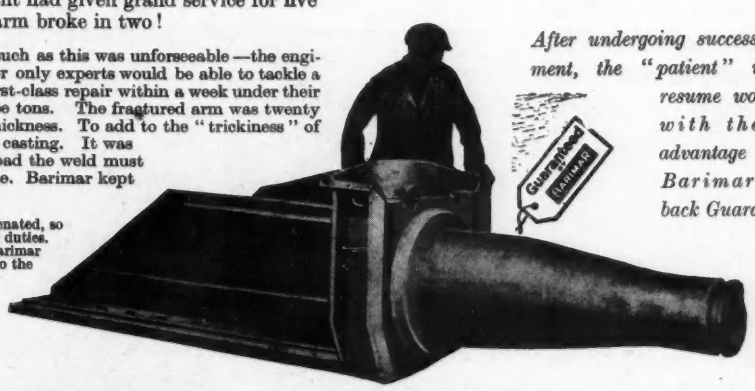

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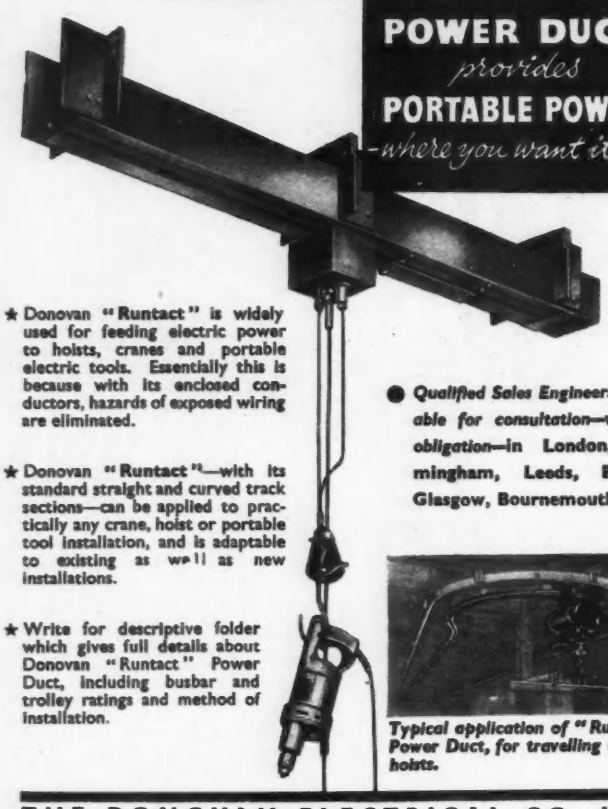

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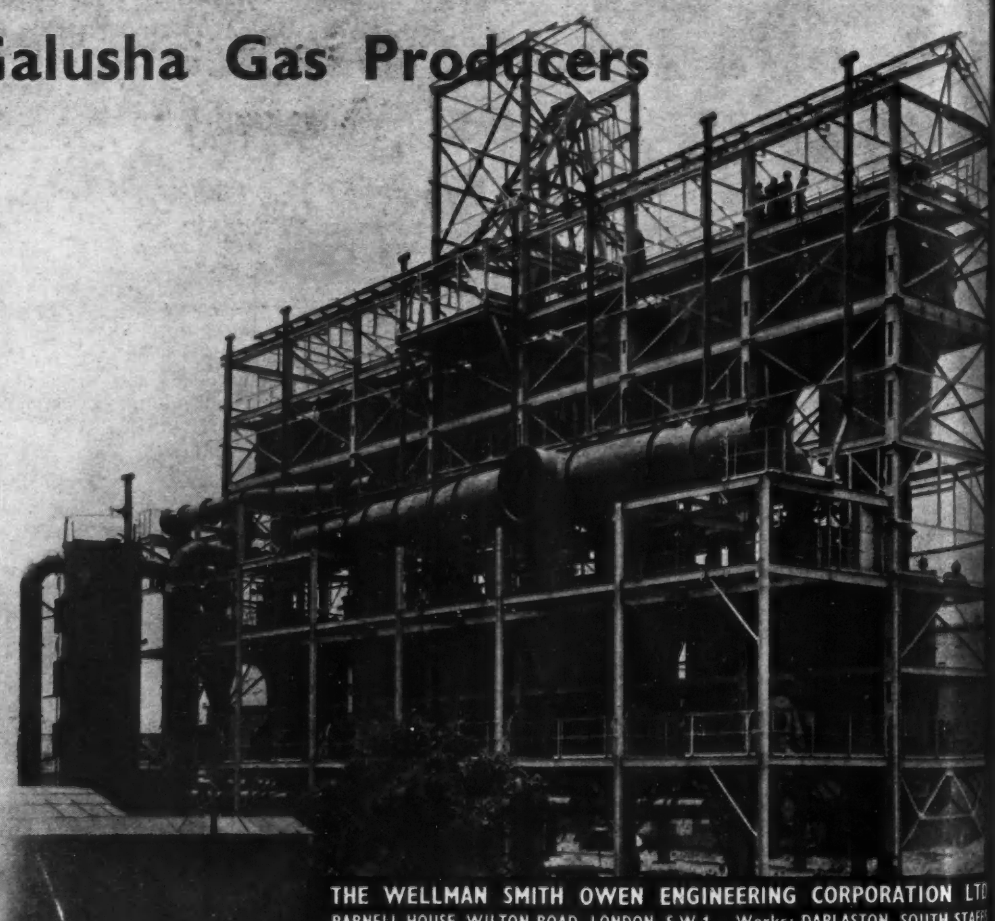

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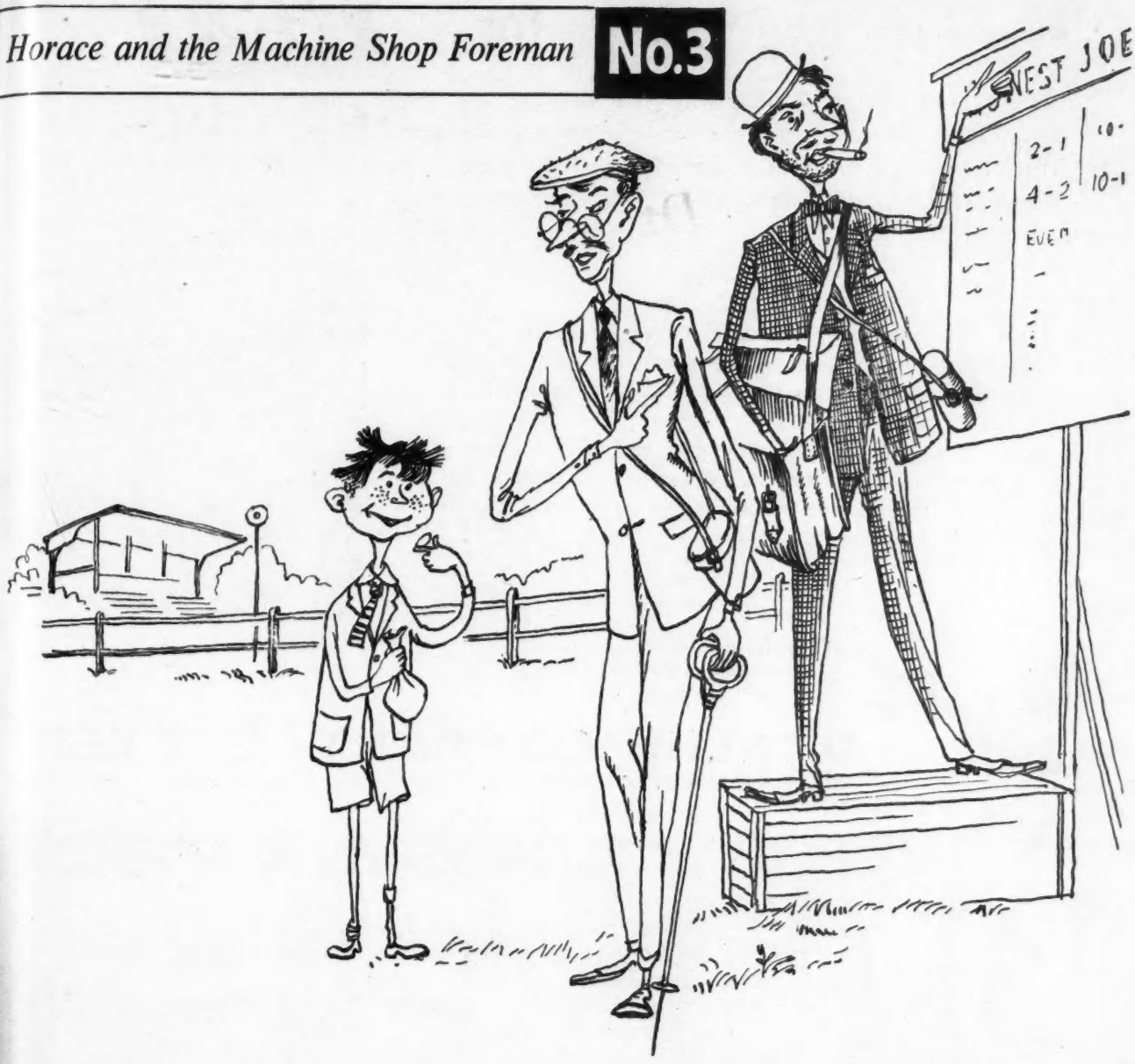
Horace and the Machine Shop Foreman **No.3**



Horace looked puzzled as the Machine Shop Foreman's half-crown disappeared into the bookmaker's cavernous gladstone. 'What,' he asked, digging an inquisitive finger into the M.S.F.'s ribs, 'is a favourite?' The M.S.F. started towards the rails. 'The favourite,' he replied, as the horses came under starter's orders, 'is the best bet . . . the one that, more than any others in its field, will repay you—and with a profit, too! That's because you're not relying on snap judgment when you invest in it, but playing safe—going by the view of the majority!' 'Oh,' said Horace, 'sounds more like Tecalemit Automatic Lubrication to me!' And he stuffed his mouth with jelly babies.

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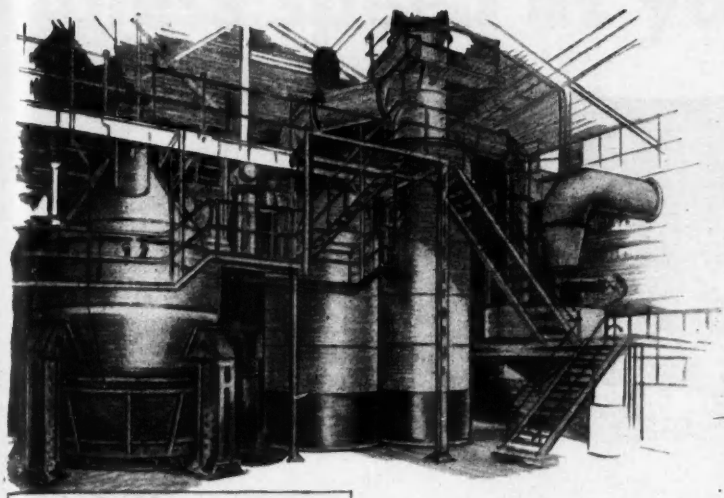

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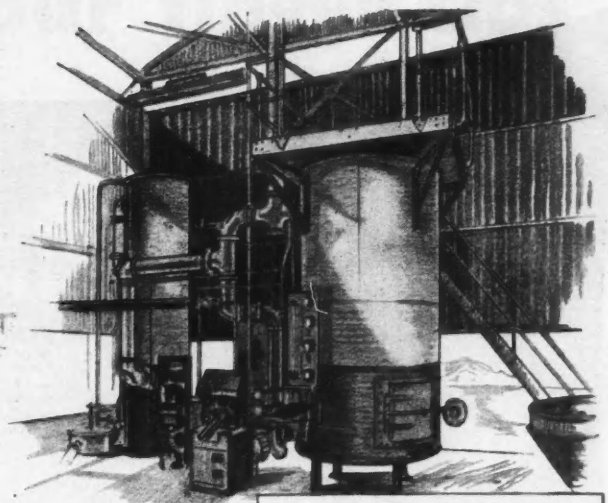

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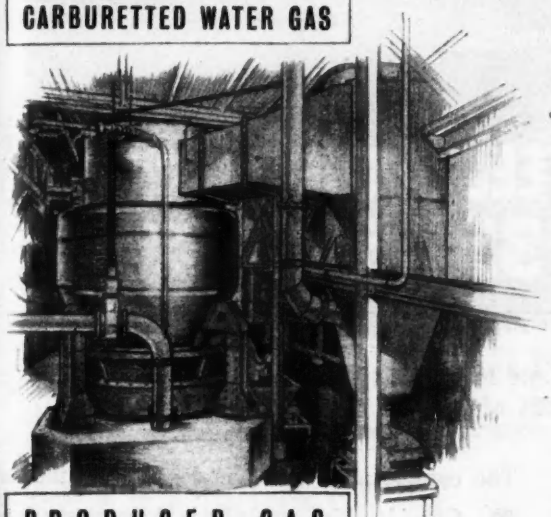

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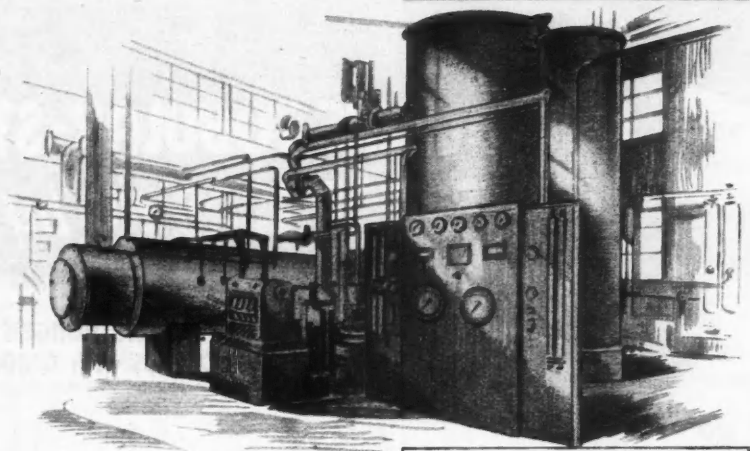

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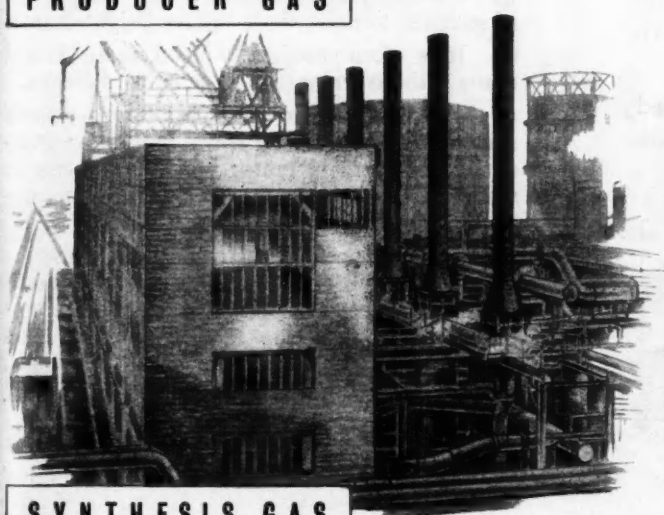

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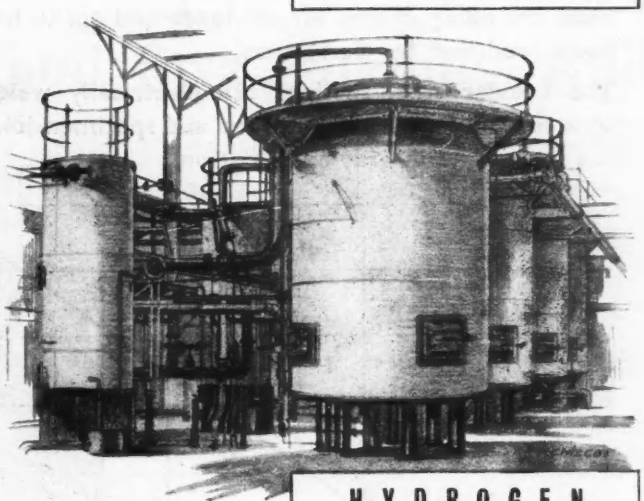

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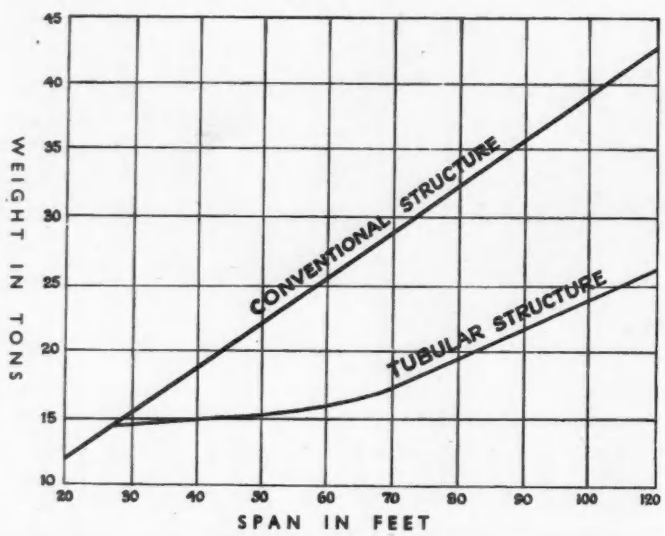

The above chart shows the comparison in weight at various spans, between a 15 ton Carruthers tubular structure-crane and an equivalent crane of riveted rolled-steel structure.

The considerable saving in deadloading means

- **Considerable economies in the construction of gantries to carry these lighter weight cranes.**
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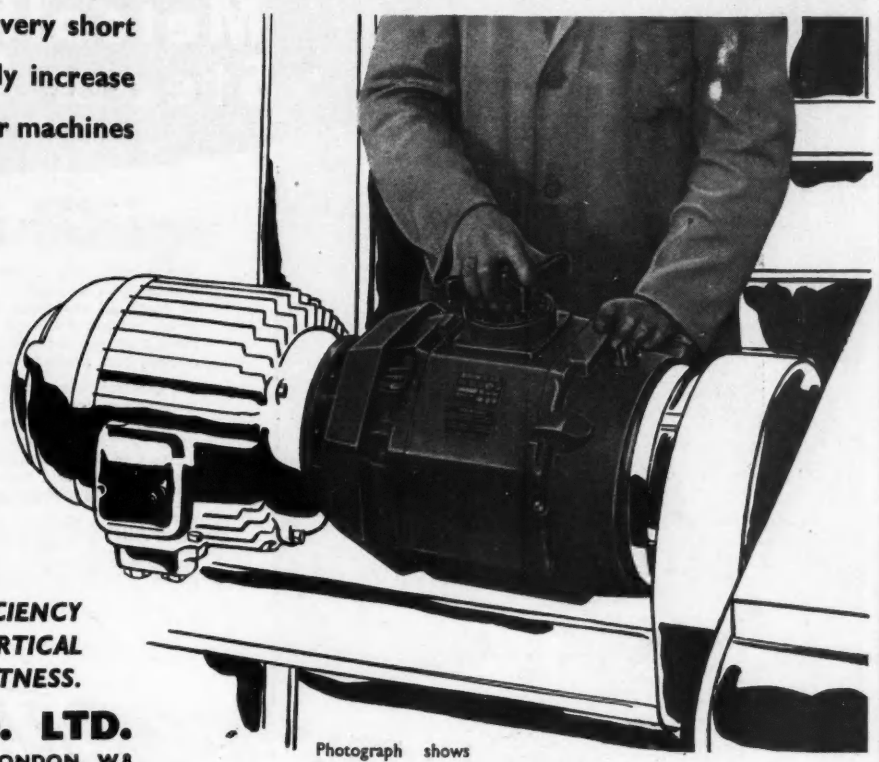

Photograph shows relative size of motor and SADIVAR.

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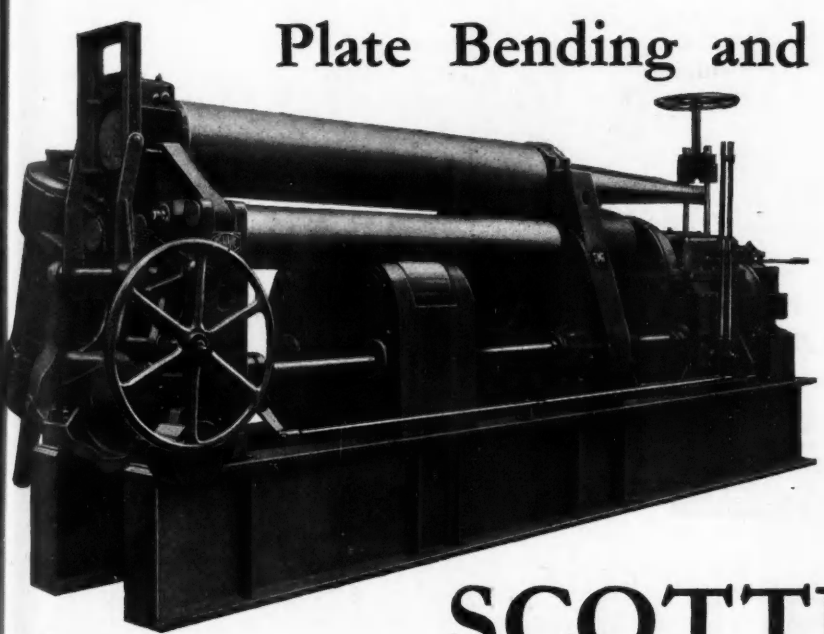

The machine illustrated is a set of Combined Bending and Straightening Rolls for dealing with mild steel plates 13′ 0″ wide x 1″ thick. A continuously running motor drives into the gear box through a flexible coupling and the various motions are obtained by hand levers operating friction clutches in the gear box.

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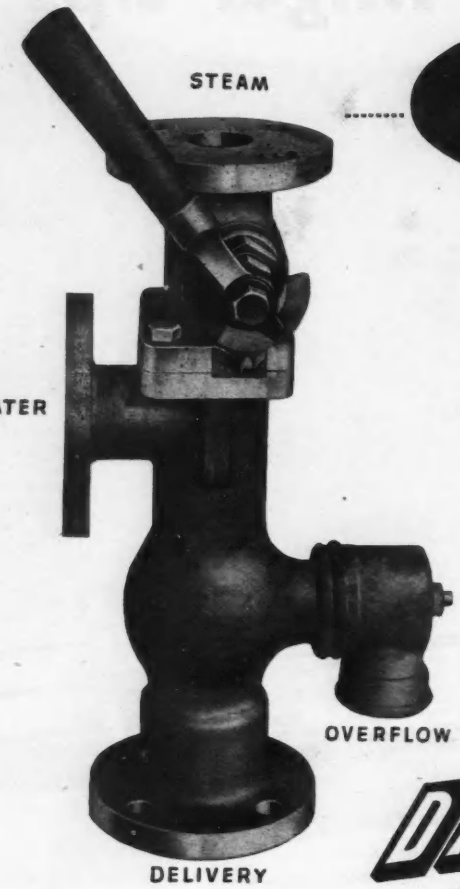

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Pattern Figure 25 Automatic Restarting Injector as illustrated

This Injector may be fixed "lifting" or "non-lifting" as required and is suitable for all types of boilers. The Injector is made in a range of sizes to cover all capacities. It is simple and reliable in operation under all conditions and low in maintenance costs. Constructed of high quality Gun Metal throughout, the Injector embodies a self-contained Steam Valve and delivery back pressure valve.

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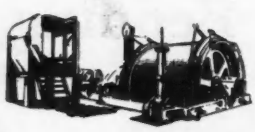
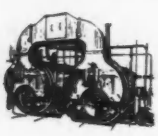
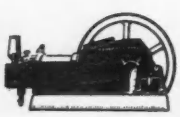


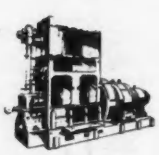
MINE WINDER



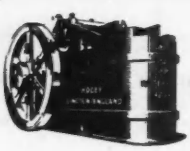
BOILER



DIESEL ENGINE



STEAM ENGINE



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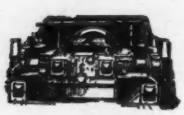

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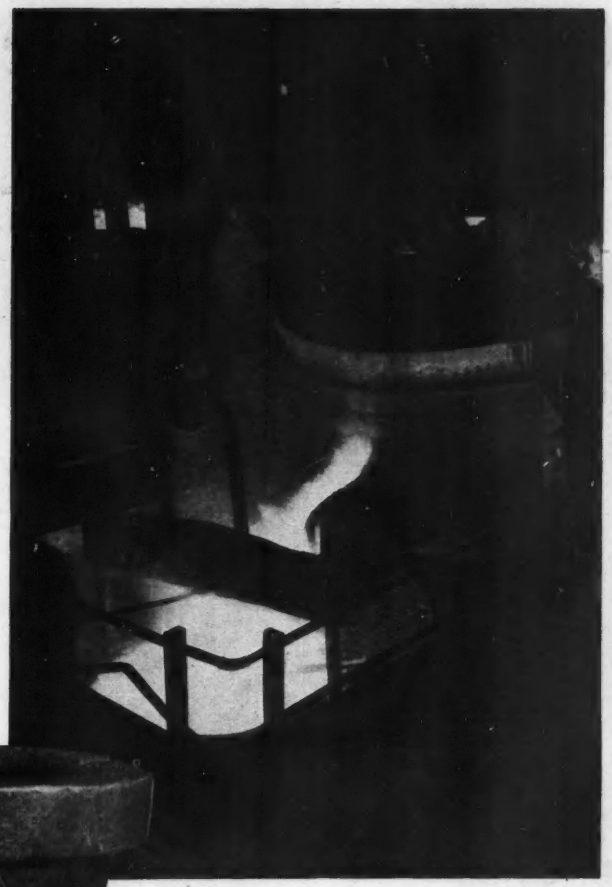

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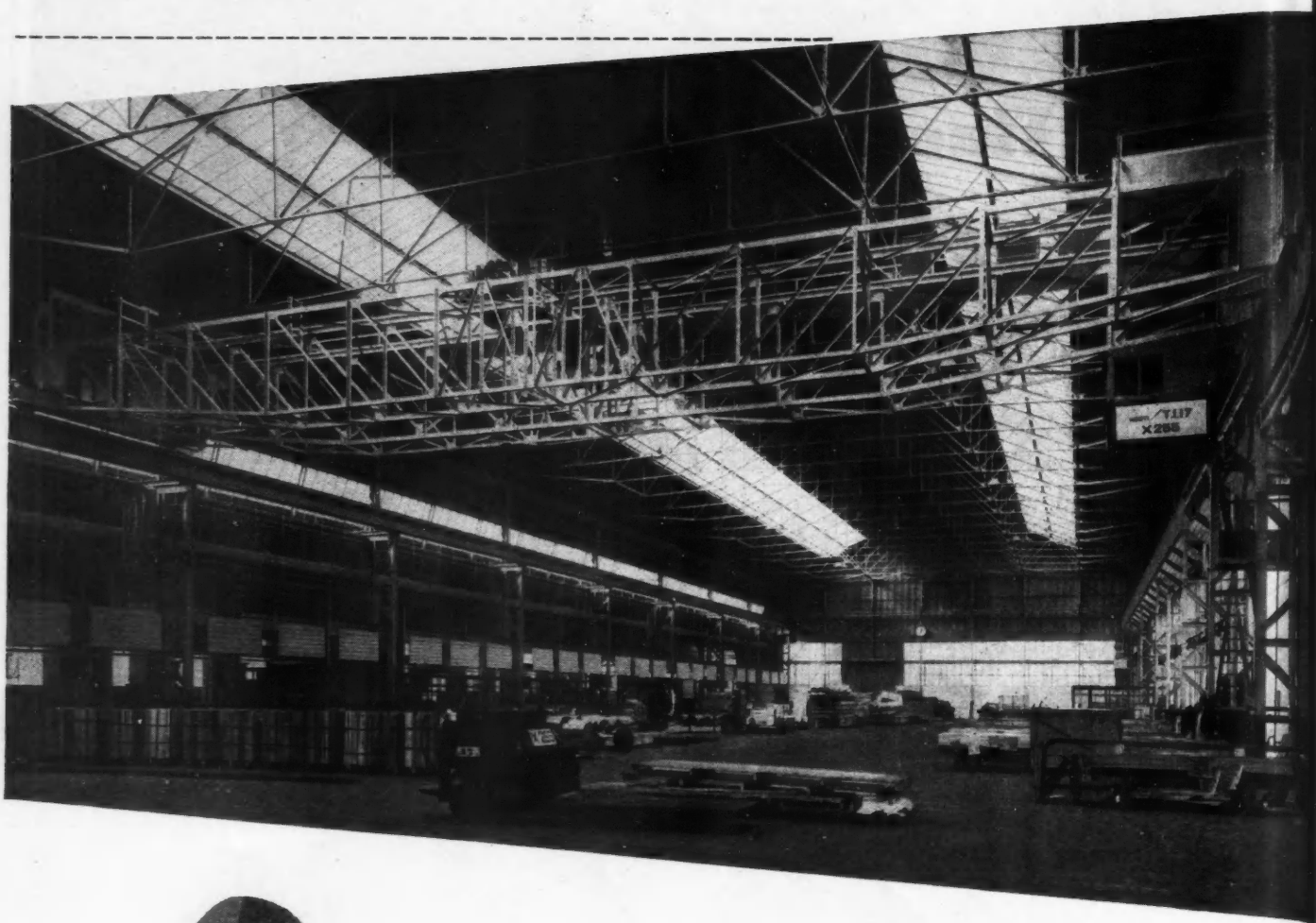

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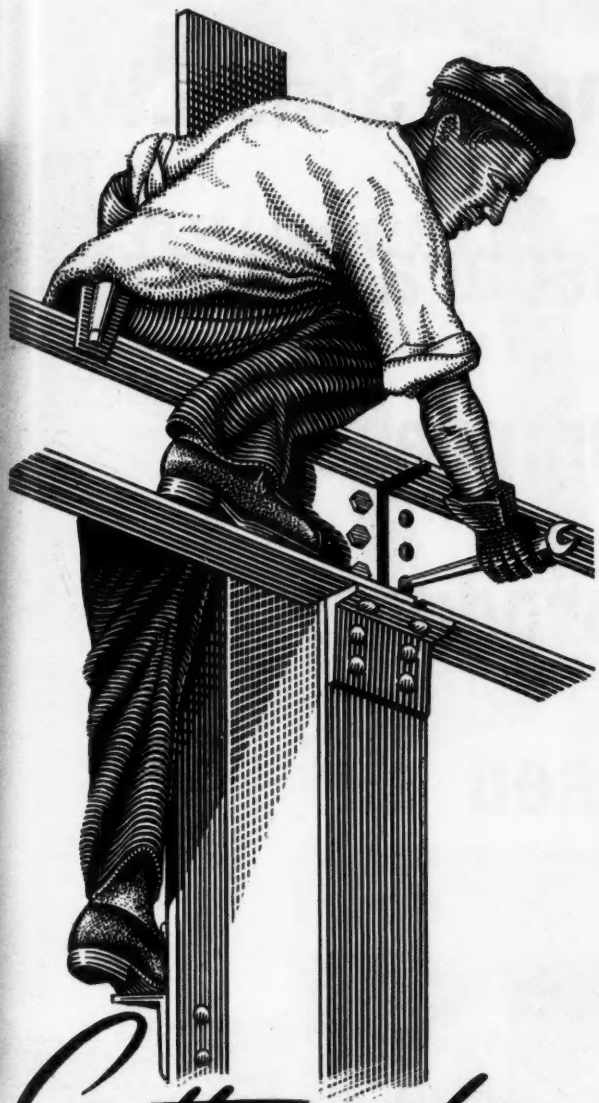

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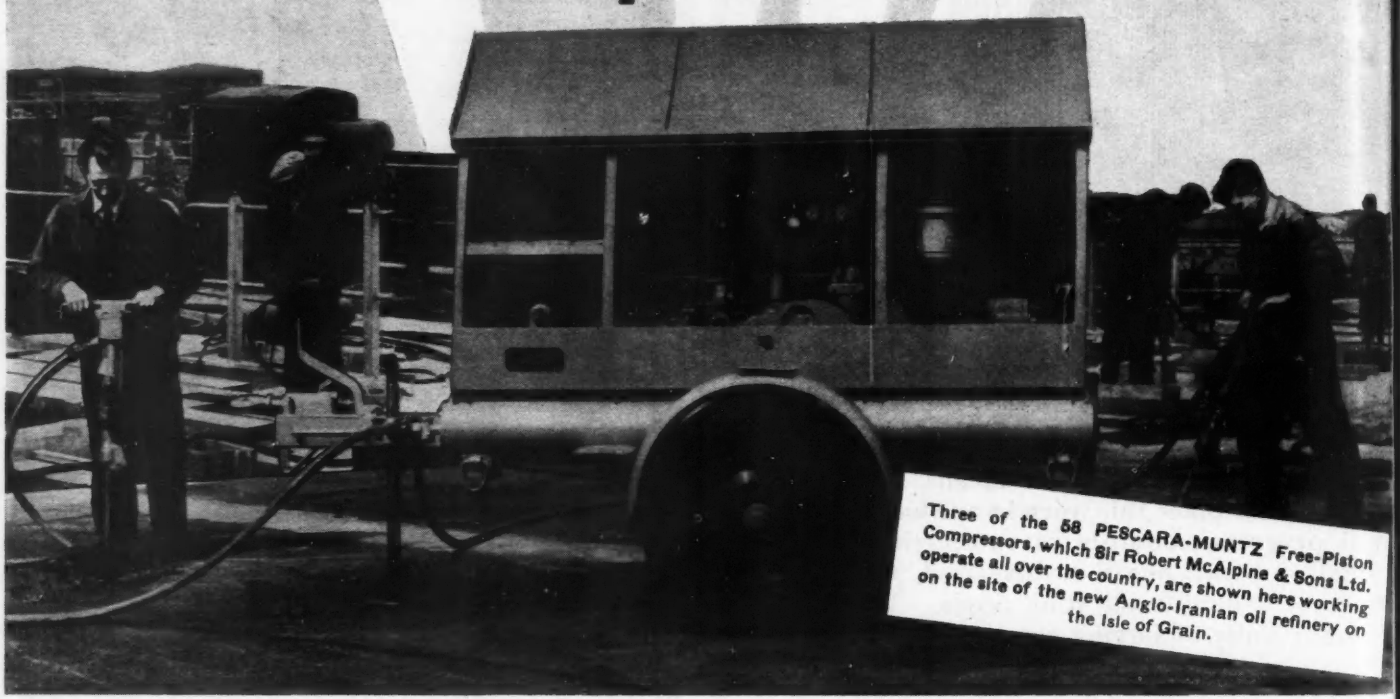

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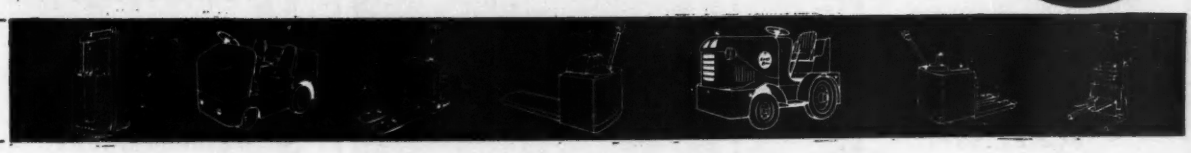

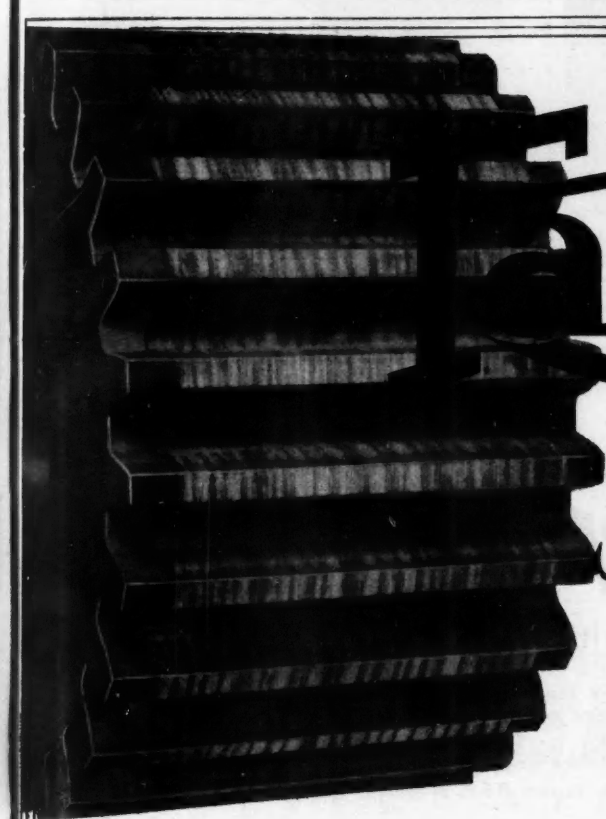

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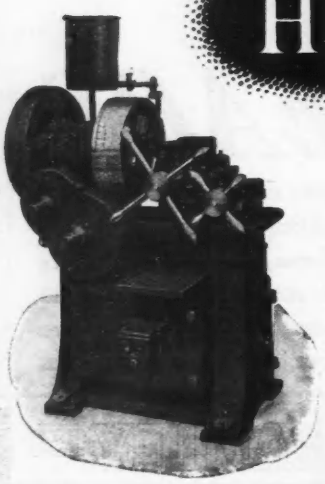

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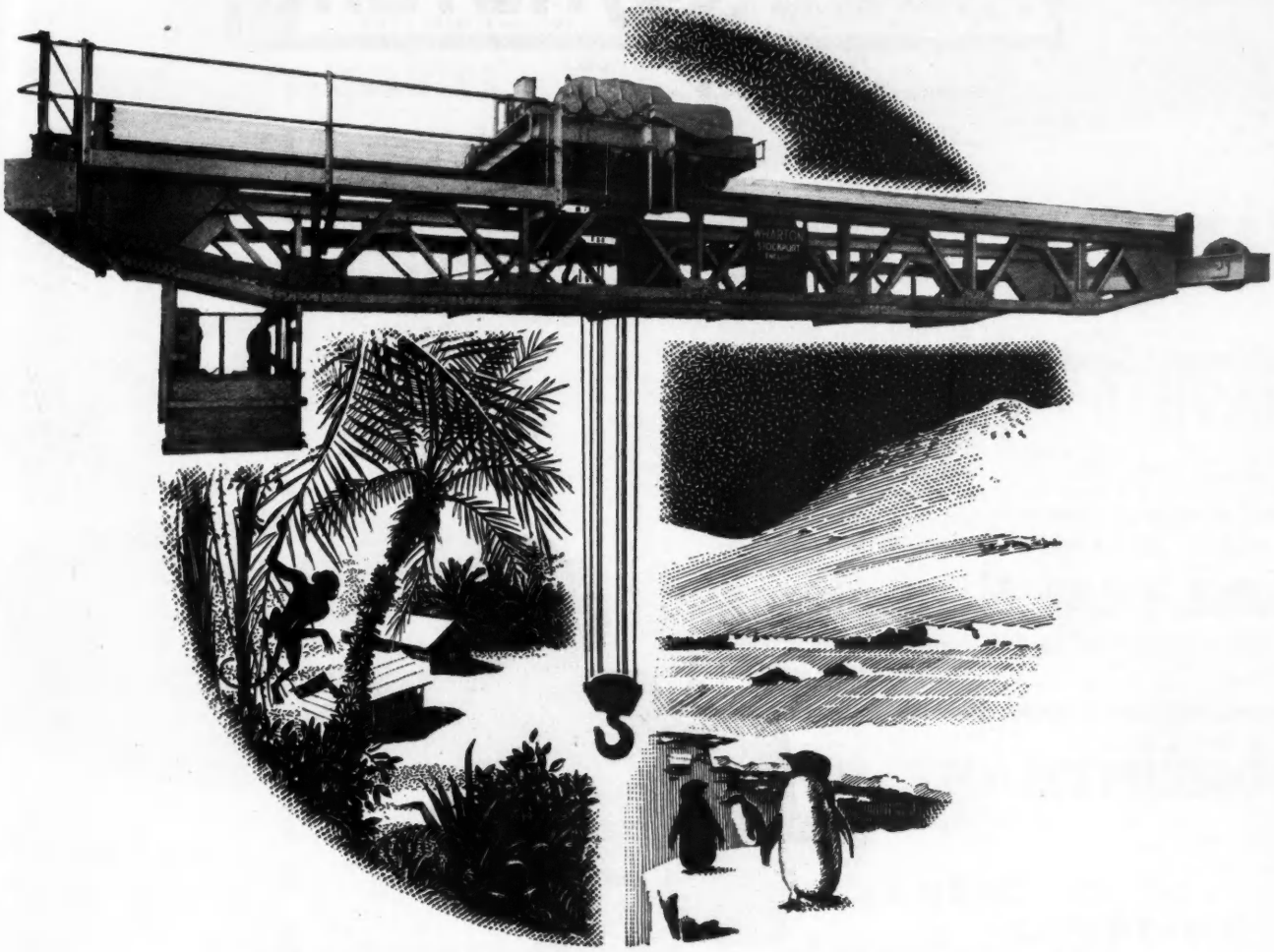

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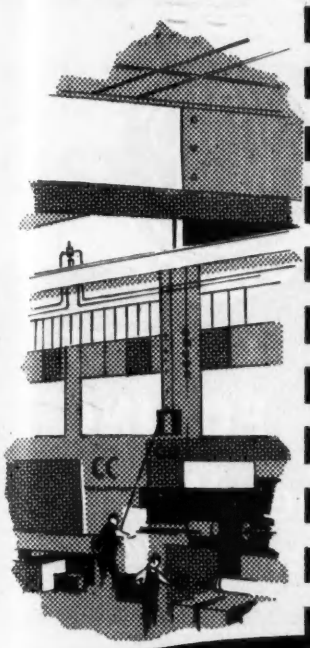

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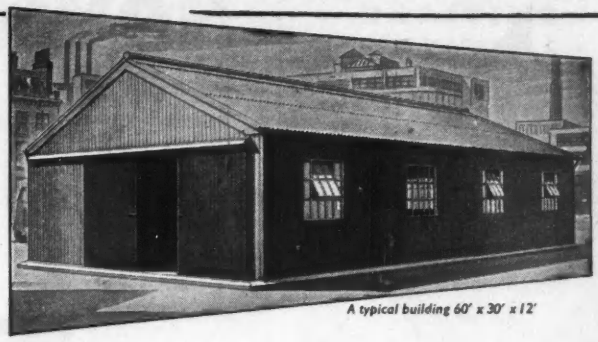

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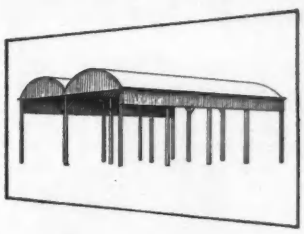

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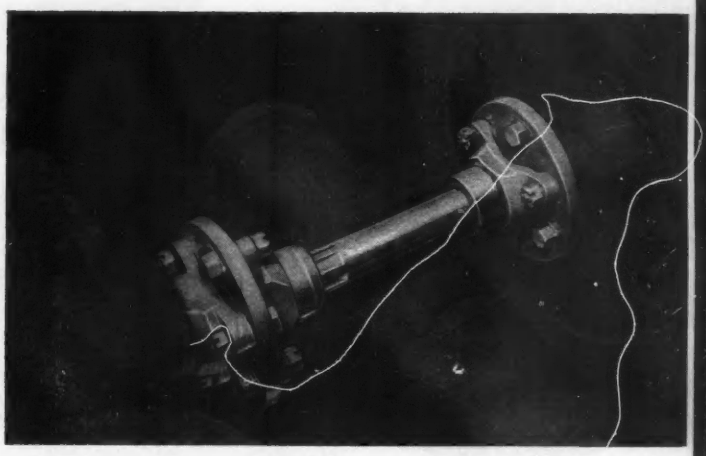

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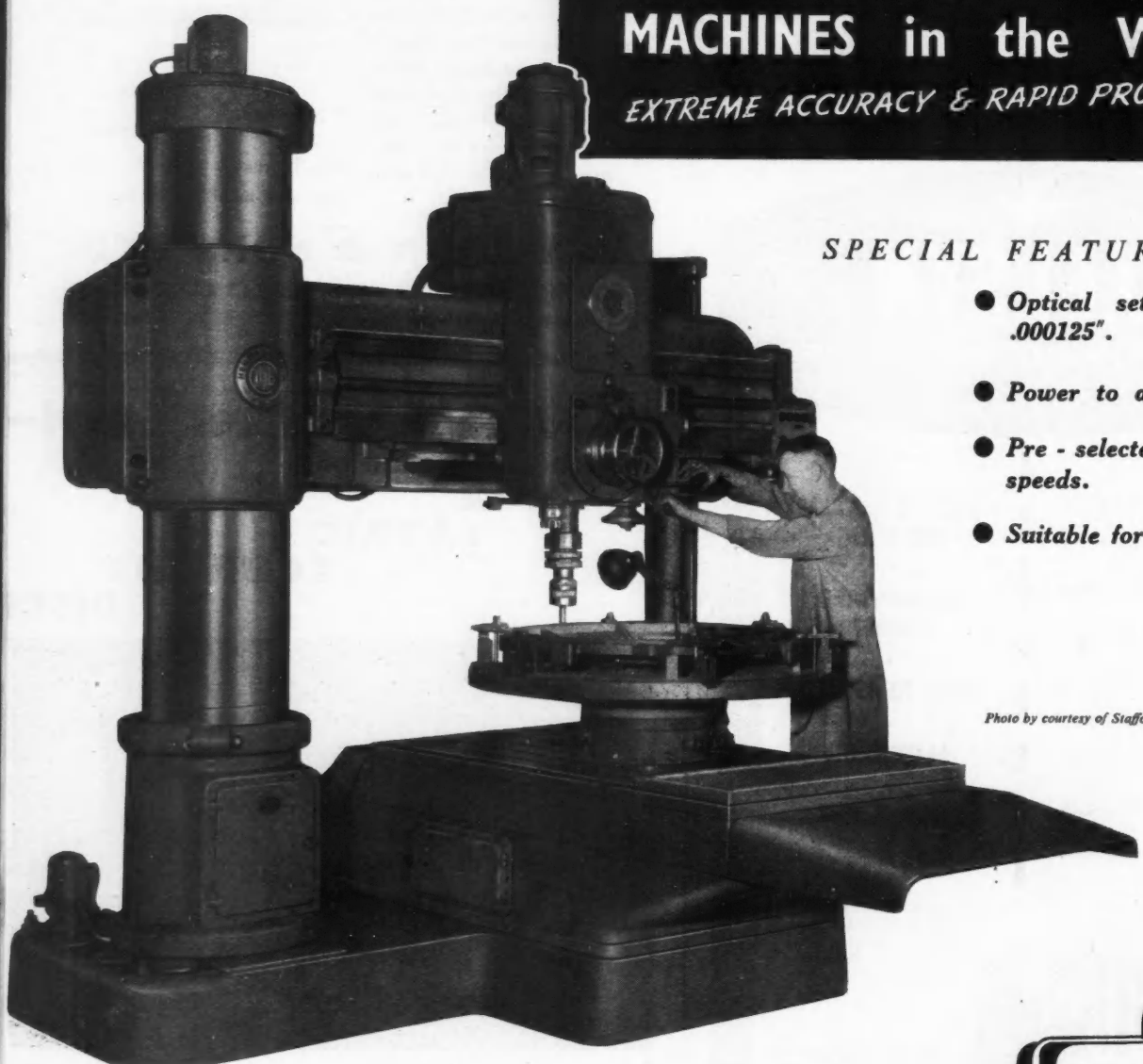

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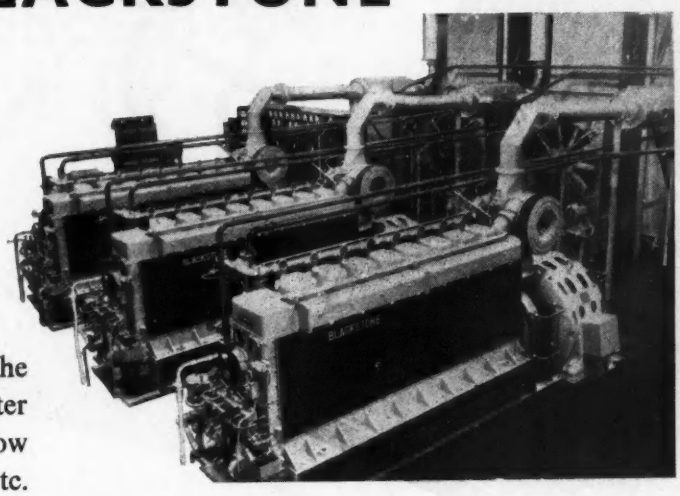

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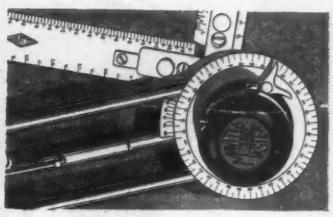

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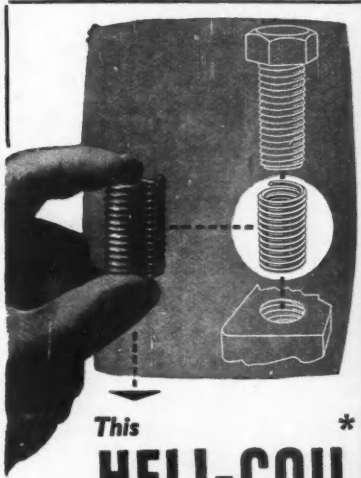

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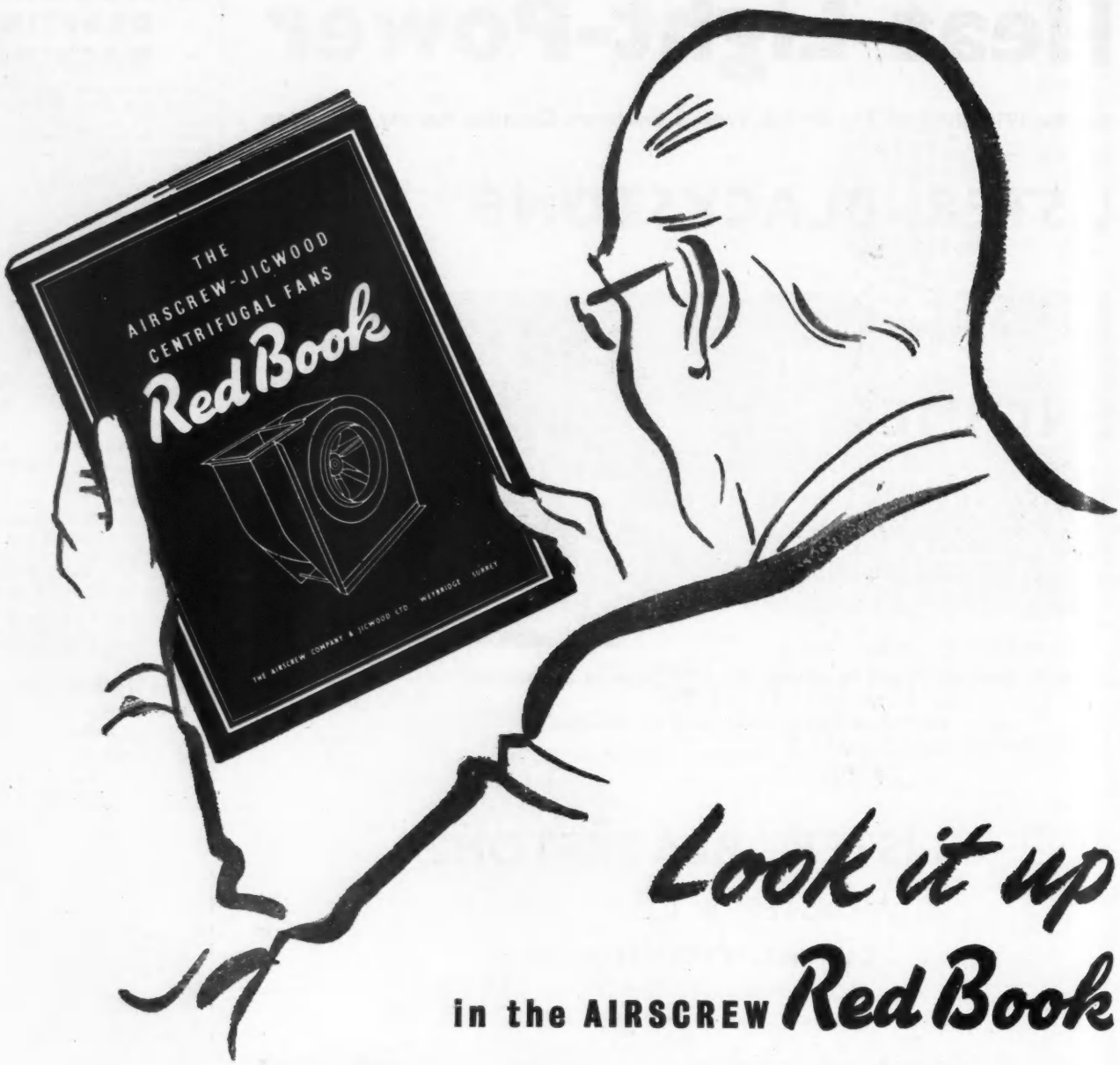

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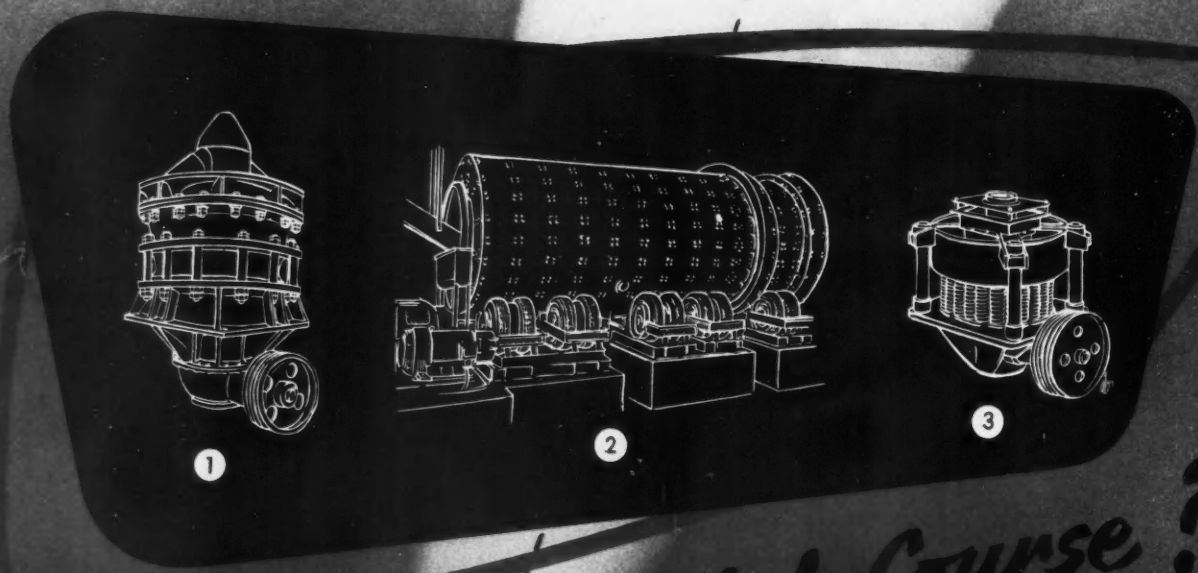

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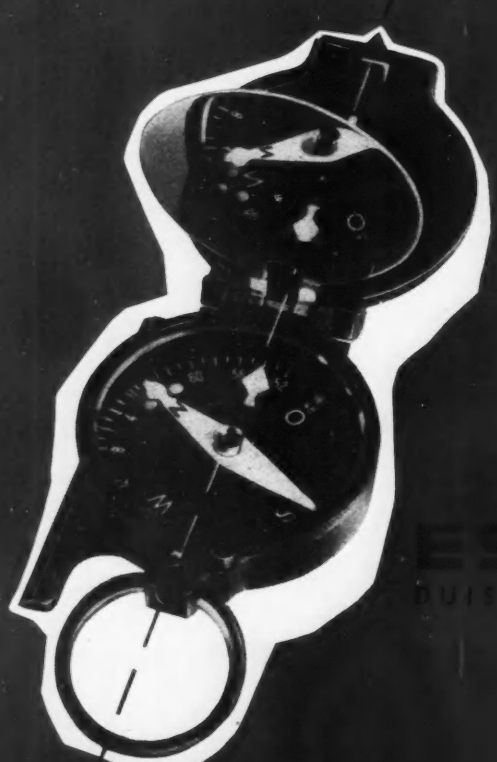

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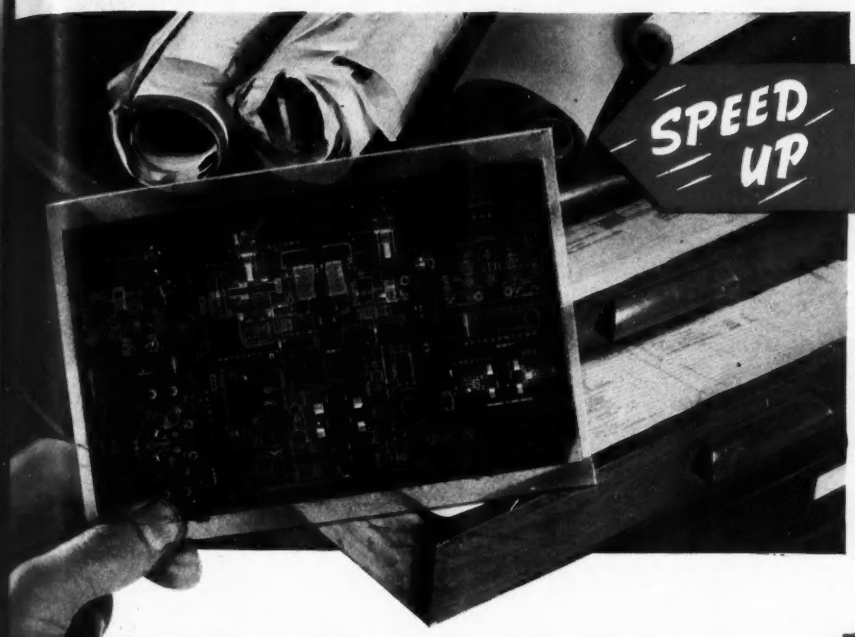

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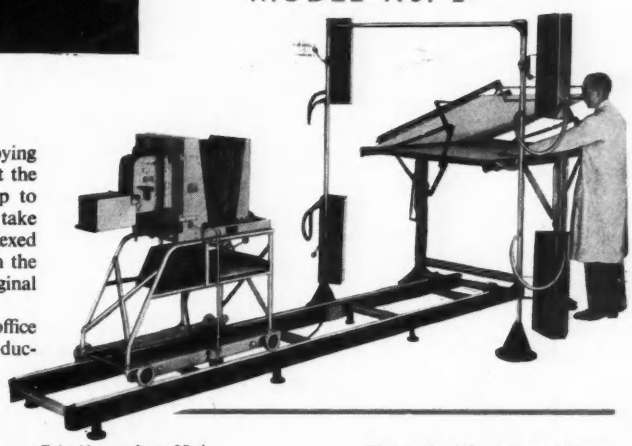

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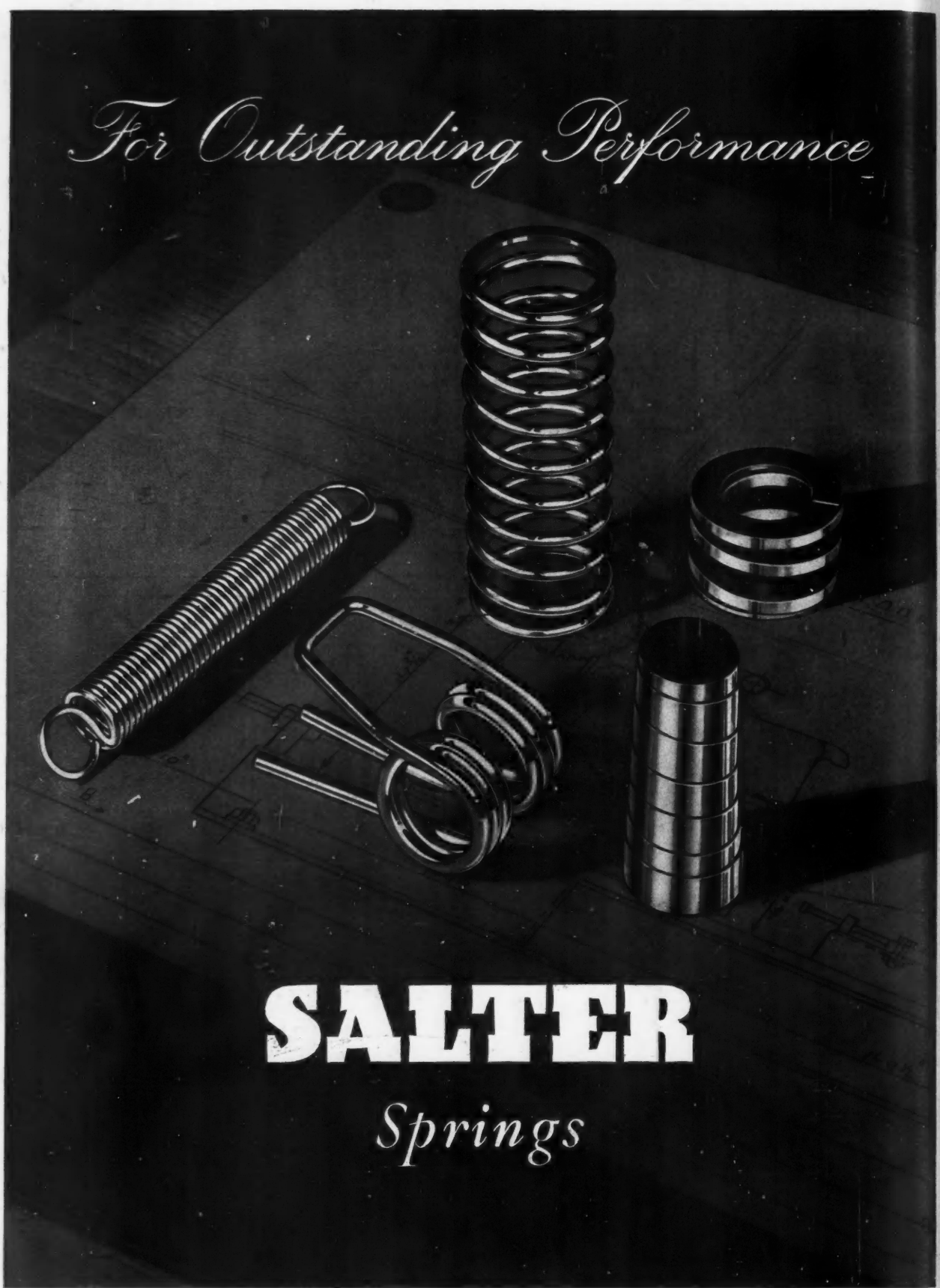

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